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Technological Adaptations at Dust Cave, Alabama (1LU496): An Evaluation of Organizational Strategies from the Late Paleoindian to the Middle Archaic

Katherine Elizabeth McMillan

University of Tennessee - Knoxville, kmcmill3@vols.utk.edu

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To the Graduate Council:

I am submitting herewith a dissertation written by Katherine Elizabeth McMillan entitled "Technological Adaptations at Dust Cave, Alabama (1LU496): An Evaluation of Organizational Strategies from the Late Paleoindian to the Middle Archaic." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

David G. Anderson, Major Professor

We have read this dissertation and recommend its acceptance:

Boyce N. Driskell, Kandace R. Hollenbach, Daniel Simberloff

Accepted for the Council:

Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

**Technological Adaptations at Dust Cave, Alabama (1LU496):
An Evaluation of Organizational Strategies from the Late Paleoindian to the Middle
Archaic**

A Dissertation Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Katherine Elizabeth McMillan
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ABSTRACT

Stone tools are one of the most common and lasting classes of artifacts in the archaeological record. Through the application of appropriate theoretical frameworks to the study of lithic assemblages, we may seek invaluable insights into the nature of human behavior in the past. In this study, I present a detailed analysis of the chipped stone tool assemblage from Dust Cave (1LU496), a stratified rockshelter site in northwestern Alabama. This site has preserved a record of nearly 7,000 years of human occupation, spanning the Pleistocene-Holocene transition, a period of great climatic and cultural change in North America.

Through the application of the Technological Organization framework, I address changes in the lithic artifact assemblage that reflect shifting behavioral strategies in the context of a dynamic natural and social environment. This approach views technology as a set of behaviors that facilitate the interaction of people with their environments, allowing tool users to meet challenges and to take advantage of opportunities presented by the natural and social worlds. With its emphasis on efficiency and decision-making, I argue that Technological Organization articulates well with approaches within Behavioral Ecology. I therefore root my analysis of the lithic materials within the Behavioral Ecology-informed studies of subsistence behavior at Dust Cave presented by Hollenbach (2005) and Carmody (2009). Together, these subsistence and lithic studies provide insight into the decisions being made by foragers in the context of a changing natural and social environment.

My technological and functional analyses reveal continuity in the range of activities represented in the toolkit, but profound changes in the position that Dust Cave occupied in the cultural system. My analysis of tool production strategies, toolkit diversity, and patterns of tool

use and discard reveals a shift from a logistically provisioned central place within an overall more residentially mobile system in the earliest periods of occupation, to a logistical station in the Middle Archaic. The richness of the environment, even in the Late Pleistocene, and the ease of raw material availability in the region had profound effects on the nature of forager decision-making at Dust Cave.

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CHAPTER 1: INTRODUCTION

A recently published project at the site of Lomekwi 3 in Kenya has produced evidence suggesting that our hominin ancestors began to produce stone tools nearly 3.3 million years ago (Harmand et al. 2015). If these dates and interpretations prove to be correct, this find pushes stone tool use back into the pre-*Homo* portion of our lineage, a realization that has great significance for our understandings of hominin evolutionary, cognitive, and cultural development.

Given their resistance to decay, lithic artifacts represent the most lasting, and sometimes the only, traces of human behavior in the archaeological record. As such, they should be viewed as potentially invaluable sources of insight into the human past. Stone tools were produced to meet a variety of technological, subsistence, and even social needs and therefore reflect a wide range of human behaviors and concerns that extend well beyond the simple production of technologies.

In spite of the great importance that stone tools hold for archaeologists, the field of lithic analysis has suffered from a lack of theory building for much of its history. Lithic artifacts have often been viewed simply as the by-products of other aspects of human behavior that are more readily studied through the application of anthropological theory. In the last several decades, however, we have witnessed a push toward viewing the production of lithic technology as an active part of human behavior and one that both influences and is influenced by other culturally-informed decisions. Through an approach labeled the Organization of Technology (Nelson 1991), the potential for lithic artifacts to provide insight into both technological and non-technological behavior patterns has become apparent. When possible, being able to root these

lithic organizational analyses in studies of environmental contexts, subsistence choices, and social pursuits bolsters the utility of this perspective. Even without such supporting data, though, the Organization of Technology is designed to allow understandings of the broader cultural context to be teased from assemblages of lithic data alone.

The work presented in this dissertation takes an organizational perspective on the analysis of the chipped stone tools recovered from the site of Dust Cave, a rockshelter in northwestern Alabama (1LU496). These tools currently are held by the University of Alabama, but are on loan to Dr. Boyce Driskell and are currently housed in the Archaeological Research Laboratory at the University of Tennessee, Knoxville. Measurement data for these artifacts may be found in Appendices A and C in this volume, and functional data are presented in Appendix B.

This research applies an organizational framework to understanding technological changes in response to environmental shifts over the course of nearly 7,000 years of occupation at Dust Cave. These occupations spanned the Terminal Pleistocene, the Early Holocene, and the initial part of the Middle Holocene, encompassing the Late Paleoindian through Middle Archaic cultural periods. Excavations, which began in 1989, revealed intact stratigraphy and produced an impressive record of faunal and botanical remains, stone tools, organic tools, and features. It is rare to find a site in the Southeast with such remarkable preservation of organic materials and such stratigraphic integrity (Driskell 1994, 1996, 2007: 45). Dust Cave therefore offers a particularly valuable window on forager adaptations in the Middle Tennessee River valley at an environmentally and culturally dynamic point in prehistory.

The site has been the subject of an extensive multidisciplinary research program, with studies focused on issues of geomorphology and site formation processes (Collins et al. 1994; Goldberg and Sherwood 1994; Sherwood 2001), paleodiet and settlement systems (Carmody

2009; Gardner 1994; Grover 1994; Hollenbach 2005; Parmalee 1994; Walker 1998), lithic raw material procurement (Johnson and Meeks 1994), the composition of the stone and bone tool assemblages (Goldman-Finn and Walker 1994; Meeks 1994; Randall 2002), the significance of canine burials (Morey 1994), and pathological and demographic patterns revealed in the human skeletal samples (Hogue 1994). Taken together, these previous studies have demonstrated shifts in subsistence pursuits, settlement strategies, and site use in response to a series of climatic and environmental changes from the Late Pleistocene into the Holocene.

The research presented in this volume, and interpreted through the application of an Organization of Technology framework, aims to elucidate the role of the lithic technology in facilitating these broader cultural changes. This approach views technology as a mediator between people and their environments, allowing humans to meet and overcome the opportunities and challenges posed by the natural and social environments. Following this perspective, decisions that are made in the production of technology necessarily articulate with decisions made in other aspects of the culture, such as the pursuit of subsistence resources and the movement of populations on the landscape. An organizational approach to lithic analysis thus enables a consideration of the range of choices made by toolmakers in the context of the decisions that guided food procurement and settlement strategies in particular environmental settings. The goal of this dissertation is to demonstrate how technological choices made by the Dust Cave population reveal broader cultural decisions from the Late Paleoindian to Middle Archaic periods. The decisions that these foragers were faced with included issues such as how to settle into and move around the landscape in order to take advantage of a variety of spatially- or temporally-restricted resources while simultaneously seeking to meet social needs.

This project benefits from the recent studies of subsistence organization at Dust Cave undertaken by Hollenbach (2005, 2009) and Carmody (2009). Both of these researchers recognized the significance of plant foods in the diets of the Dust Cave occupants and worked to create models of foraging decisions that drew on understandings from the field of Behavioral Ecology. Their results revealed active decision-making on the part of foragers in organizing site use, settlement patterns, and dietary selection according to spatial and temporal availability of resources. Their models provide an elegant framework into which the current study of forager technological organization may be incorporated, with the aim of providing an additional perspective on decision-making in cultural systems in the human past. Through a detailed analysis of decisions that were made at the levels of raw material acquisition, tool design, production, use, maintenance, and discard, this study considers how those technological choices reflect a constant negotiation between technological challenges and settlement-subsistence challenges within a shifting natural and cultural environmental setting.

The Paleoindian-Archaic transition has received substantial attention in eastern North American archaeology, including in the Southeast. This transitional phase has been of great interest to archaeologists for most of a century, with each successive generation of scholars further elaborating and refining our understandings of these periods. As the end of the Paleoindian period and the beginning of the Archaic coincided with major global environmental changes – namely an increase in global temperatures, the retreat of continental ice sheets, and major shifts in faunal and botanical communities – the archaeological record from this time highlights the dynamic and adaptable nature of human culture.

The ways in which these early inhabitants of the Southeast adapted to changing local conditions has been a subject of great interest almost since the initial recognition of these

occupations in the region. In his discussion of the Pleistocene inhabitants of the Southeast, Griffin (1952: 353) proposed that these populations likely “were organized into small groups, probably of closely associated family units whose activities were limited to rather restricted hunting areas and who utilized the various native floral products for food.” Although his work was based on limited available evidence, this statement presented an initial interpretation of Southeastern Paleoindian lifeways, including a view of social organization and settlement-subsistence patterns. His image of the earliest occupations in the Southeast stood in contrast to behaviors interpreted from early sites in the Southwest, where Paleoindian materials in North America had first been recorded. At sites like Blackwater Draw and Folsom, distinctive projectile point styles had been uncovered in association with the remains of extinct megafauna, a discovery that pushed the antiquity of humans in the Americas well into the past and prompted an initial view of Paleoindians as “big game hunters.” In contrast to the patterns suggested by these finds in the Southwest, Griffin (1952) suggested that megafauna may not have been widespread in the East because of comparatively unfavorable ecological conditions, and, as a result, archaeologists should not expect to find human artifacts in association with the remains of extinct fauna. His mention of the exploitation of “floral products” and an emphasis on “ecological conditions” highlights what would become common themes in studies of the lifeways of the earliest occupants of the Southeast: varied diets that incorporated a great emphasis on plant foods, and a focus on the dynamic relationship of people and their environments. Griffin’s (1952) views on the Archaic period, while also based on minimal available data, presented a view of post-Pleistocene lifeways as reflecting increasing familiarity with and adaptation to local resources within more rigidly defined territories.

By the latter part of the 1950s and into the 1960s, several stratified sites had been discovered in the Southeast (e.g., Hardaway, NC [Coe 1964]; Graham Cave, MO [Logan 1952]; Russell Cave, AL [Miller 1956, 1957]), which prompted archaeologists to begin defining cultural sequences for the region and refining assemblage information for the more finely resolved cultural stages that were emerging. Consideration of these cultural sequences, some of which were dated using the newly-introduced radiocarbon method, demonstrated differences through time in artifact inventories by period and encouraged archaeologists to begin asking questions about the changing nature of Paleoindian and Archaic lifeways and settlement patterns. Caldwell's (1958) *Trend and Tradition in Eastern United States Prehistory* was one such example of a focus on understanding changing settlement-subsistence strategies, a problem he considered with reference to contemporaneous ecological patterns. He proposed that the earliest inhabitants of the East, who migrated from boreal forests in the north, would have been faced with the challenge of familiarizing themselves with a new suite of available resources upon migrating from the comparatively resource-poor boreal forest region into the much richer Eastern Woodlands. He intimates that the subsistence strategies of the earliest foragers would have been relatively inefficient, before populations became accustomed to the resources that this new region offered. Caldwell's (1958) views on the Archaic inhabitants of the region foreshadowed several interpretations that continue to inform our understandings of these early occupations. He suggested frequent wandering on a yearly cycle, with populations exhausting locally available resources before moving to a new locality; he noted the emergence of great regional diversity in projectile point styles; he introduced the notion of differing cultural expressions in different ecological contexts; and he highlighted the use of a wide variety of subsistence resources. Even

at this time, the connection between ecological conditions and cultural expressions was becoming apparent.

A decade later, Griffin (1967) echoed this perspective, explaining that early aboriginal populations became increasingly familiar with locally available resources and adapted to particular ecological contexts. To Griffin, the Early Archaic period, immediately following initial occupation of the region by Paleoindian groups, represented “the period of initial cultural changes and adaptations to the food and industrial resources of the varied postglacial environments of Eastern North America” (Griffin 1967: 178). He proposed that this “intervening tradition” was marked by varied subsistence pursuits (hunting, gathering, trapping, and netting) and increasing seasonality in these activities (Griffin 1967: 178). Toolkits remained essentially unchanged from the preceding period, with the exception that fluted point forms were replaced by unfluted types, and eventually by a great variety of forms that possessed notched and stemmed bases. The technology also became more varied, as assemblages of unifacial tools made from flakes and blades appeared alongside woodworking and plant processing implements. New geographical and ecological zones began to be inhabited as evidenced by the discovery of occupation debris in caves and rockshelters (e.g. DeJarnette et al. 1962; Fowler 1959; Logan 1952), as well as at deeply buried river bottom sites (e.g. Broyles 1971; Coe 1964; Lewis and Kneberg 1958; Soday 1954). All of these patterns reinforced the view of increasing familiarity with the environment, and adaptations to local conditions.

This process of localized adaptations continued into the Middle Archaic, a period that witnessed an increase in ground stone technology, fishing implements, bone and antler tools, and increased dependence on freshwater and ocean shellfish in areas where they were available.

Griffin (1967) suggested that sites with large shell heaps represented recurrent occupation of these favorable, resource-rich areas, and signaled increased sedentism.

In the wake of Caldwell's (1958) work, researchers in the Southeast have continued to pursue interpretations of prehistoric lifeways, beyond simply documenting and describing material patterns. The application of middle range theories – those theories that seek to link the material traces in the archaeological record with the behaviors that produced them – has provided a means to interpret behavior patterns from the archaeological record (e.g., Binford 1979, 1980). Beginning in the 1970s and 1980s, the addition of paleoenvironmental reconstructions (e.g., Delcourt and Delcourt 1981, 1985) to these middle range interpretations allowed archaeologists in the Southeast to consider the role of local environmental conditions and climatic fluctuations in shaping the adaptive responses of foragers. Studies began to focus on the links between the nature of the environment and the nature of cultural systems, including settlement strategies, subsistence practices, and the accompanying technological responses (e.g., Chapman 1973, 1975, 1977; Claggett and Cable 1982; Smith 1986; Steponaitis 1986).

This ecological focus became elaborated in the late 1980s and into the 1990s when archaeologists in the region began to consider not only environmental determinants of settlement-subsistence and technological strategies, but also biocultural needs that drove the selection of those strategies (e.g., Anderson and Hanson 1988). Researchers began to recognize that the need for information exchange, mate acquisition, and the formation of social networks would have exerted as strong an influence on hunter-gatherer organizational strategies as did climate conditions and resource distributions.

The research presented in this dissertation continues in this vein, attempting to understand how foragers adapted to changing environmental circumstances from the Late

Pleistocene (Late Paleoindian) into the Middle Holocene (Middle Archaic). A technological perspective is taken on this issue, as the central goal of this project is to understand how technological systems were designed and executed in order to facilitate the accomplishment of shifting subsistence goals and settlement strategies, which constituted responses to the changing structure of the environment. This goal is addressed by considering:

1. the composition of toolkits throughout the occupation of Dust Cave. Toolkits are defined through comprehensive descriptions of the tools and range of types associated with the various periods of site occupation (see Chapter 4).
2. the ways in which those toolkits change through time. Changes in the composition of toolkits as well as changes in the frequency of particular tool types are discussed.
3. the reasons for these technological changes. This project addresses why these shifts occur and what broader behavioral changes they represent. By relating technological changes to the adaptive shifts seen in the subsistence data, this project considers how changes in technological organization served to facilitate the accomplishment of broader cultural goals.

Chapter 2 presents an overview of the site and the history of research as well as a review of the climatic and environmental conditions to which foragers adapted from the Late Pleistocene into the Middle Holocene. Chapter 3 presents a discussion of the theoretical frameworks employed and referenced in this dissertation: Behavioral Ecology and the Organization of Technology. The Dust Cave typology and an overview of the materials examined are presented in Chapter 4. The following two chapters present discussions of the technological (Chapter 5) and functional (Chapter 6) analysis methods used in this research. Because a significant part of understanding how technologies are organized and how they

articulate with settlement-subsistence needs depends on understanding the nature of the tasks in which tools were employed, this project considers functional as well as technological interpretations of the lithic assemblage. The results of the technological and functional analyses are presented in Chapters 7 and 8, respectively. Finally, Chapter 9 concludes the volume, presenting a consideration of how the Dust Cave technological patterns articulate with those Behavioral Ecology-informed understandings of forager subsistence decisions presented by Hollenbach (2005, 2009) and Carmody (2009).

CHAPTER 2: DUST CAVE IN ENVIRONMENTAL AND ARCHAEOLOGICAL CONTEXT

The research presented in this dissertation employs data from the site of Dust Cave (1Lu496), a stratified rockshelter site in Lauderdale County, Alabama (Figure 2.1). Research done to date on the materials from this cave suggests that the locale was used as a habitation site for nearly 7,000 years, from the Late Paleoindian (corresponding to the Younger Dryas, ca. 12,850-11,700 cal yr BP; Anderson et al. 2015: 7-9) to the Middle Archaic (ca. 6,000 cal BP; Sherwood et al. 2004: 533). Excavations revealed approximately 5 meters of complex stratigraphy deposited, in large part, through anthropogenic processes. Systematic excavation of these deposits has revealed a finely resolved sequence of lithic tools and debris, faunal and botanical subsistence remains, organic tools, occupation surfaces and a variety of feature types.

This exceptional site integrity and preservation makes Dust Cave notable for several reasons in the context of early Southeastern archaeological sites. First, in contrast to many early open-air sites in the Southeast, there is little evidence for deflation of the deposits and resultant component mixing. Instead, archaeological components associated with diagnostic artifact types are well separated. This stratigraphic separation has allowed analysts, myself included, to catalog and interpret the nature of the changing technological and subsistence assemblages through time. Second, there has been minimal natural disturbance of the stratigraphy through erosion or flooding, contributing to the lack of component mixing in the deposits. Third, the exceptional organic preservation in the limestone cave microenvironment, in a region where prolonged periods of heat and humidity create prime conditions for organic decay, provides a rare opportunity for paleobotanical and faunal analysts to interpret the prehistoric subsistence

economy using direct evidence. Finally, unlike other well known and more easily accessible cave sites in the region, the relative inaccessibility of Dust Cave protected it from non-natural disturbance of the deposits, including vandalism and looting.

Even early in the history of the project, the significance of these finds in the archaeological record of the Midsouth was easily recognized. Goldman-Finn and Driskell (1994: 4) wrote “Preservation of the stratified deposits, along with the integrity of the site matrix and the quality of organic remains, are reasons to suggest that Dust Cave is unprecedented as a resource in Late Pleistocene to Early Holocene archaeology of the Tennessee Valley and the Midsouth.” Anderson (1994: 237) echoed these sentiments, stating “I believe in years to come the excavations at Dust Cave will play a major role in shaping our understandings of early human occupations in the Midsouth and across the larger Southeast.” More than 20 years later, the great significance of this site continues to be apparent (Driskell 2009).

DISCOVERY AND INITIAL INVESTIGATION

Discovery of the site is attributed to Dr. Richard Cobb, a spelunker and avocational archaeologist who performed a survey of caves in the region in 1984. Dr. Cobb mapped the interior of Dust Cave and recovered several pieces of bone and lithic materials from the inner chamber. He reported this site, along with several others, to the Alabama Cave Survey and to the Alabama State Archaeological Site File. Dust Cave was not tested until 1989 as part of a contract with the Tennessee Valley Authority (TVA) to locate and evaluate cultural resources in the area of the Pickwick Reservoir (Goldman-Finn and Driskell 1994: 5).

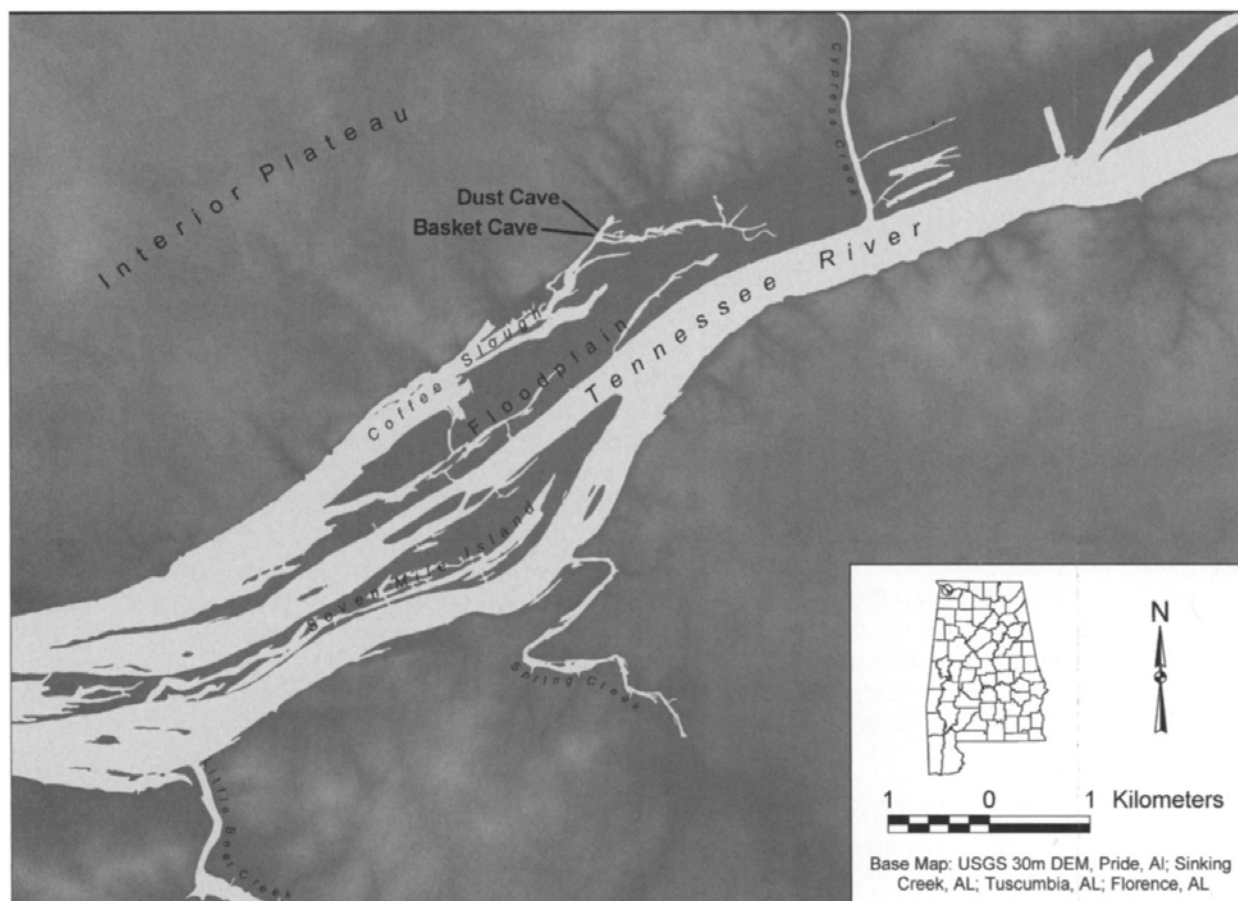


Figure 2.1: Location of Dust Cave. (From Sherwood et al. 2004: 534).

Initial investigation of Smith Bottom Cave, located west of Dust Cave (Figure 2.1), was undertaken by the Alabama Museum of Natural History in 1984 and 1989. Dr. Boyce Driskell, from the University of Alabama, later undertook additional investigations of Smith Bottom Cave and several other caves in the area as part of the university’s archaeological field school program. During the summers of 1988 and 1989, Driskell and his students investigated numerous caves in the region, and their excavations at Smith Bottom cave revealed the “potential for deeply buried, well-preserved early aboriginal remains” (Goldman-Finn and Driskell 1994: 5) at other cave sites in the area, such as Dust Cave. Upon recommendation from Dr. Michael Collins

from the University of Texas, Austin, Dust Cave was selected as a location worthy of further investigation.

In 1989, Driskell and his students began excavation of five 50 cm x 50 cm test units in the cave and, at the end of the field season, the presence of cultural materials was confirmed when investigators uncovered a small number of chert flakes located in layers of darker sediments. These early excavations revealed complex stratigraphy, lithic debitage, formal tools, and bone, including both a human and a dog burial (Goldman-Finn and Driskell 1994: 6). Over the following several years, field school participants expanded the original test units, both horizontally and vertically, and excavated a large trench on a north-south axis into the entrance chamber (Figure 2.2). Excavation of this trench allowed detailed examination of the site stratigraphy, which has figured prominently in interpretations of site formation and function. Later field schools expanded the horizontal extent of the excavations until much of the main chamber was exposed.

The lack of disturbance and exceptional preservation noted in the excavations make Dust Cave an important resource for understanding the Pleistocene-Holocene transition in the Southeast. The archaeological assemblage uncovered through these excavations provides researchers with a rich dataset for approaching a wide variety of research topics related to this important period of environmental and cultural transition, including:

site formation, economic and subsistence studies, technological change, and settlement systems. The Dust Cave assemblage of well-preserved bone, charred plant material, and lithic artifacts offers a rare glimpse into foraging behavior in the Midsouth from its Paleoindian beginnings into the Middle Archaic (Sherwood et al. 2004: 534).

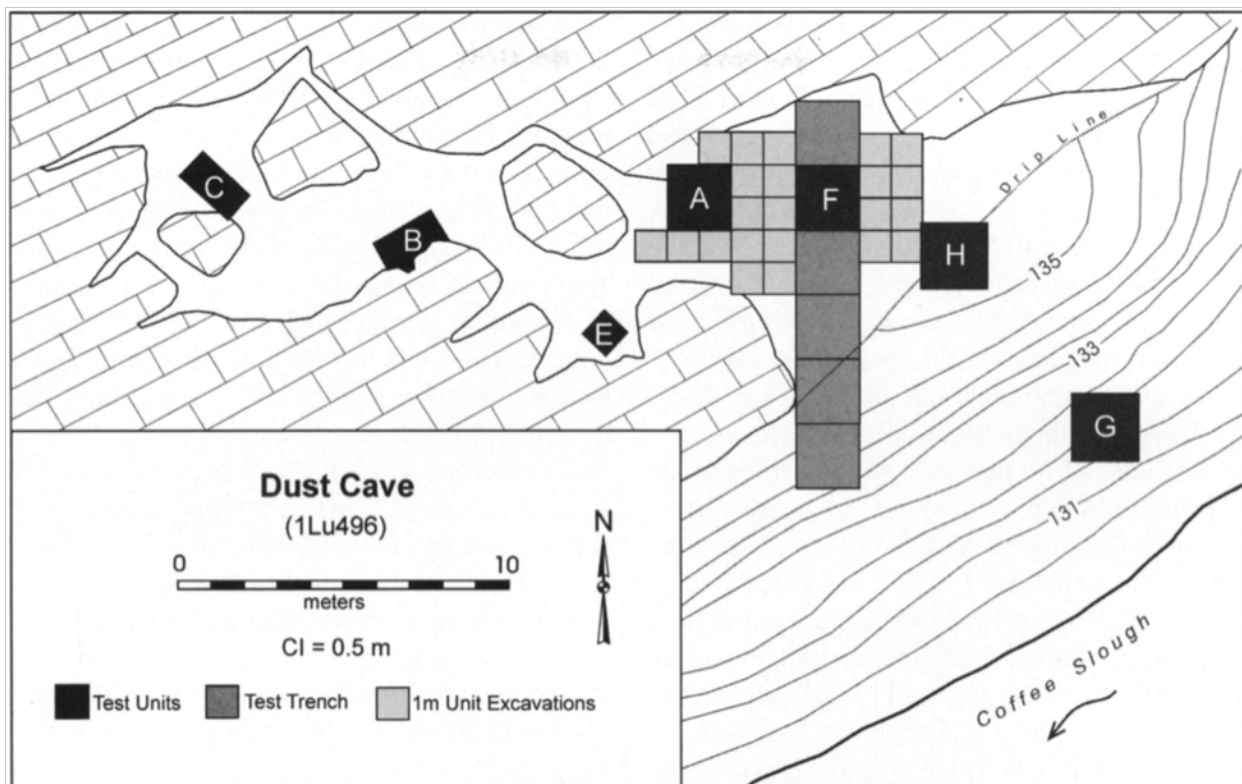


Figure 2.2: Plan of Dust Cave Interior. (From Sherwood et al. 2004: 535)

DUST CAVE CHRONOLOGY: OVERVIEW OF ARCHAEOLOGICAL COMPONENTS

The finely resolved stratigraphy (Figure 2.3), in addition to the exceptional preservation of organic remains, has produced a robust series of 43 radiocarbon dates that allow the Dust Cave deposits to be partitioned into five distinct archaeological and chronological units that are associated with diagnostic hafted biface styles (Figure 2.4). Single projectile point types or clusters dominate four of these archaeological units, specifically the Early Side-Notched, Kirk Stemmed, Eva/Morrow Mountain, and Benton phases. In the lowermost strata, the fifth archaeologically defined unit represents Late Paleoindian occupations and has produced several projectile point styles including Quad, Beaver Lake, Dalton, Hardaway Side-Notched, and a

reworked Cumberland. A brief overview of the nature of these components and their associated cultural materials is provided below.

Quad/Beaver Lake/Dalton Component (12,650 – 12,000 cal BP)

The earliest use of Dust Cave is dated to 12,650 cal BP (Sherwood et al. 2004: 544). This period of occupation coincides roughly with the onset the Younger Dryas, a climatic oscillation characterized by an intense cold reversal that began ca. 12,850 cal BP and lasted until approximately 11,700 cal yr BP, and the end of which is considered to represent the end of the Pleistocene (Anderson et al. 2015: 7). The entrance chamber was largest at this time, and the focus of human activities appears to have been near the front of the cave, where living conditions were interpreted as being drier (Homsey 2004: 45). The feature assemblage, which was dominated by charcoal stringers (charcoal altered by fluvial activities) and also included charcoal pits and charcoal/ash concentrations, suggests that the Late Paleoindian occupation of the cave may have been an ephemeral one. Homsey (2004: 45) notes, however, that the apparently minimal use of the cave during the Late Paleoindian may be an artifact of post-depositional processes, including scouring of the deposits by periodic flooding at the end of the Pleistocene.

Artifacts recovered from the deposits associated with this occupation include hafted bifaces, specialized blades produced from prepared cores, a variety of blade tools, and “temporally diagnostic unifaces, including blades, thumbnail scrapers, and gravers” (Sherwood et al. 2004: 544). In addition to chipped stone tools, a range of organic implements was recovered that includes antler tines, bone awls, and a bone needle (Goldman-Finn and Walker 1994, Sherwood et al. 2004: 546).

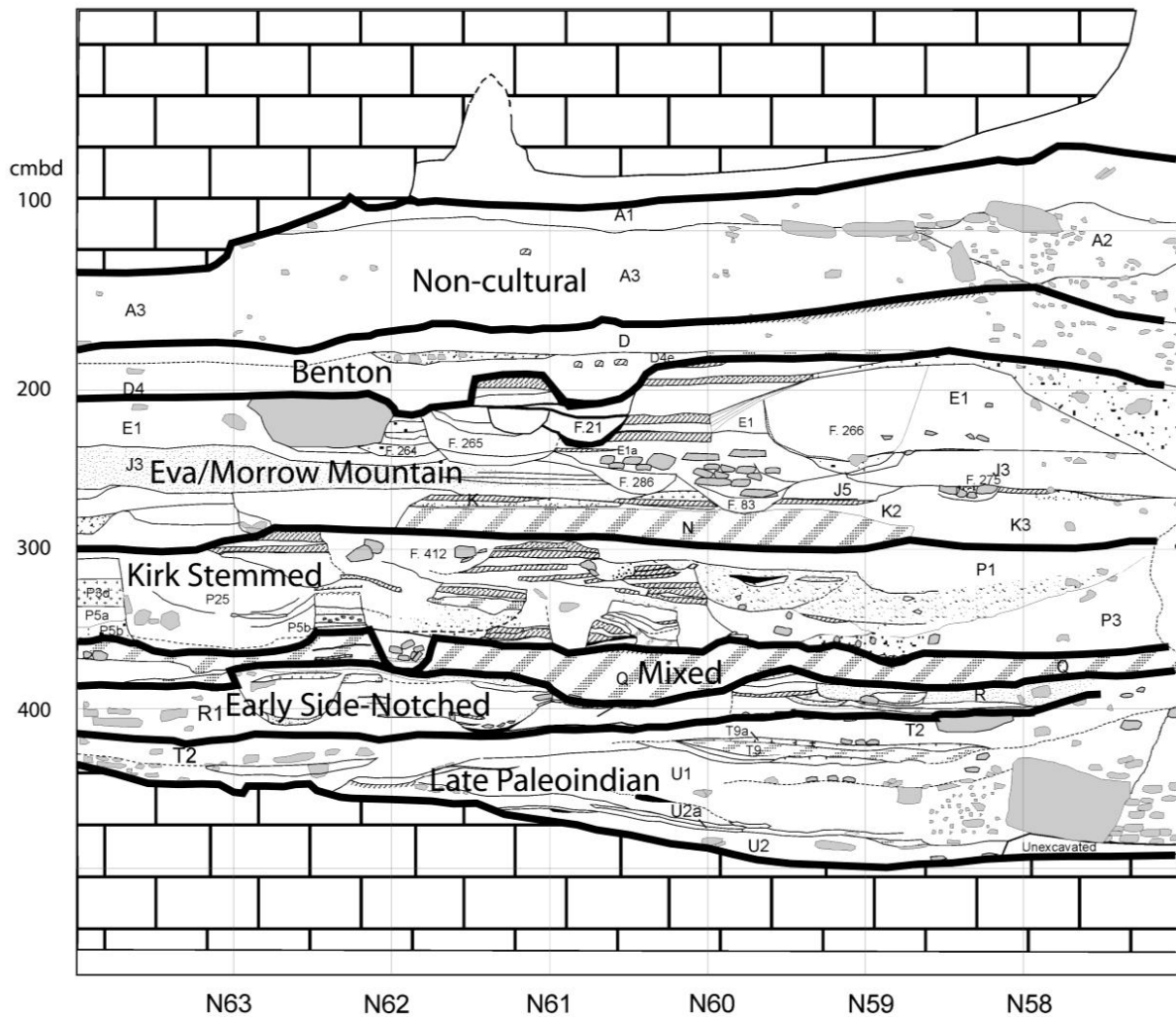


Figure 2.3: Dust Cave Stratigraphy showing general zones and depths. (From Carmody 2009: 21; adapted from Sherwood et al. 2004: 537).

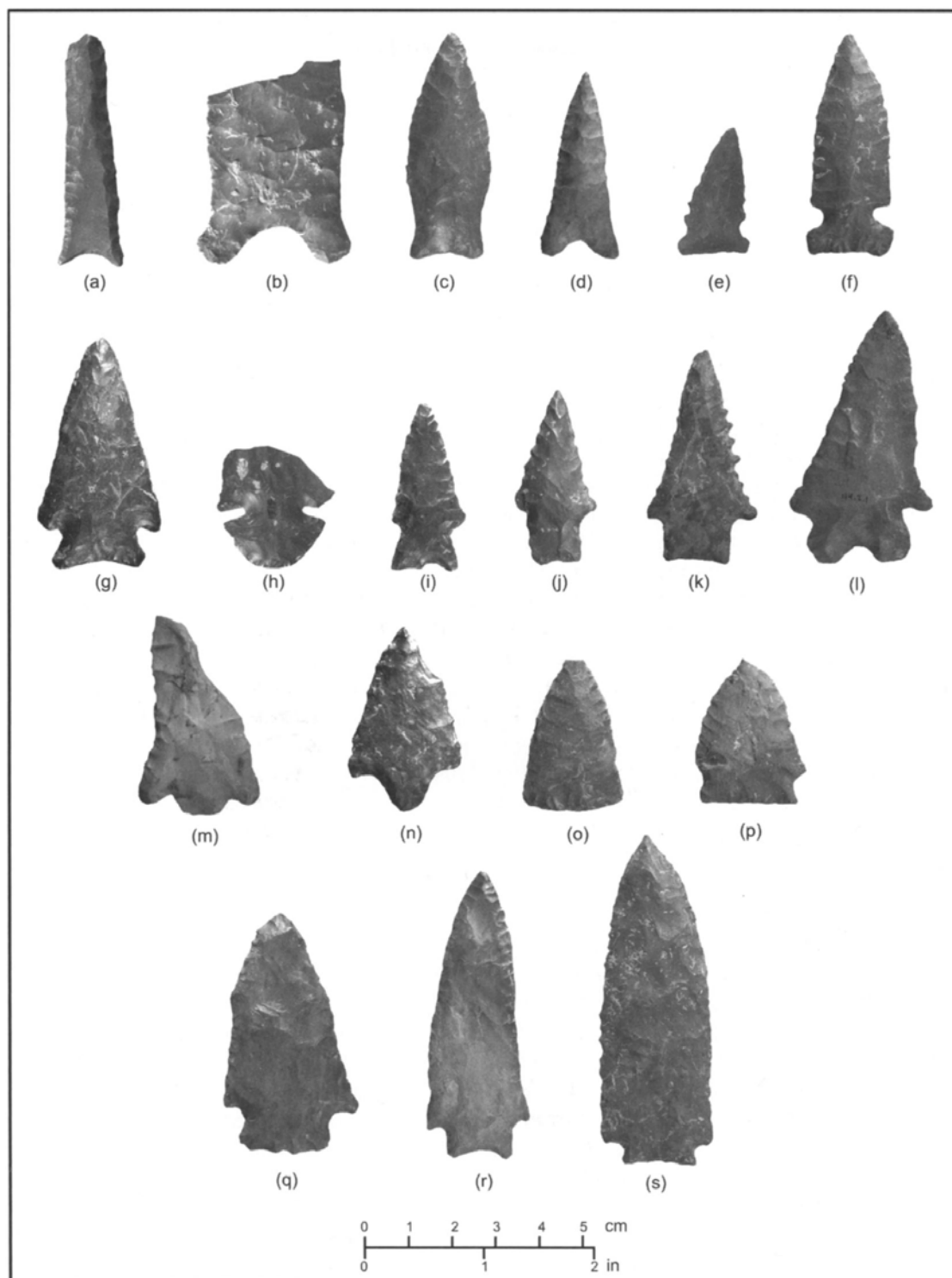


Figure 2.4. Hafted Biface Styles from Dust Cave. (From Sherwood et al. 2004: 545).
(a) Cumberland, (b) Quad, (c) Beaver Lake, (d) Dalton, (e) Hardaway Side Notched, (f) Early Side Notched, (g) Kirk Corner-Notched, (h) Plevna, (i) Kirk Stemmed, (j) Kirk Stemmed, (k) Kirk Serrated, (l) Kanawha, (m) Eva, (n) Morrow Mountain Stemmed, (o) Morrow Mountain Straight Base, (p) Crawford Creek, (q) White Springs, (r) Buzzard Roost Creek, (s) Benton

The faunal assemblage demonstrated a greater reliance on avian species in the Late Paleoindian period than in any other time period and revealed a particular emphasis on migratory waterfowl (Walker 1998). Other identifiable animal remains from the Late Paleoindian period include various mammals and a small quantity of fish, reptile and amphibian remains. Plant remains recovered from the Late Paleoindian deposits are suggestive of the exploitation of edible and weedy seed taxa, in particular *Chenopodium*.

Early Side-Notched Component (12,000 – 11,000 cal BP)

Early Archaic deposits at Dust Cave are characterized by Early Side-Notched projectile points and represent a cultural component associated with the onset of the Holocene. Occupation activities were focused in the west-central portion of the entrance chamber, indicating increasing aridity in the interior of the cave (Homsey 2004: 48). The feature assemblage is suggestive of a variety of activities, including cooking, nut processing, and refuse disposal (Homsey 2004: 48). Prepared occupation surfaces and small pits, as well as dense concentrations of artifacts characterize the Early Side-Notched levels and suggest intensive site occupation at this time (Sherwood et al. 2004: 547).

The density of artifacts in this component is very high, which implies that the Early Side Notched period may represent one of the most intensive periods of occupation in the cave's history. The dense concentration of lithic debitage is highest in this component, suggesting a great emphasis on tool manufacture and maintenance (Hollenbach 2005: 262). The blade industry that characterized the Late Paleoindian deposits appears to have decreased in importance in the Early Side-Notched period, as the focus shifted more toward the use of bifacial tools (Randall 2001 in Sherwood et al. 2004: 547). Other artifacts recovered include expanded

base drills, stage bifaces, hafted and unhafted unifaces, and a variety of bone tools, including antler tines, a grooved antler handle, bone awls and needles (Goldman-Finn and Walker 1994; Sherwood et al. 2004: 547).

This technological shift may reflect changing use of faunal resources from river/floodplain species to terrestrial species (see Walker 1998: 166). The paleoethnobotanical record suggested an overall increase in plant use from the Late Paleoindian period (Hollenbach 2005: 159-160), including a peak in the use of fruits (Carmody 2009: 94). While the presence of particular taxa changed little from the preceding period, differences were noted in the density of certain taxa, such as the decrease in hazel and black walnut and the increased use of wild legumes, chenopod, and hackberry (Hollenbach 2005: 161-164). The use of avian species dropped in comparison to their high prevalence in the preceding Late Paleoindian period, while use of mammals and fish increased significantly (Walker 1998: 136).

Kirk Stemmed Component (8,900 – 8,300 cal BP)

The Kirk Stemmed period appears to have witnessed significant changes in the use of Dust Cave. Features are clustered in the east-central portion of the cave, where it is suggested headroom was greatest (Homsey 2004: 48-49). The number of features increased dramatically, and new feature types emerged. The Kirk Stemmed deposits are characterized by stacked, prepared clay surfaces that cover a much wider area of the cave than in previous periods. In addition to these prepared surfaces, pit hearths and expedient hearths were common on the east side of the cave, while ash pits dominated the western portion (Homsey 2004: 48-49). Homsey suggests, based on the overlap of cooking and nut processing features in the cave, that conservation of space was a primary concern to the Kirk Stemmed inhabitants. A clear

separation between domestic and refuse disposal activities was noted, which she proposes “may signify that the occupants anticipated stays of longer duration than in earlier occupations and that they made a greater effort to keep the living/sleeping areas clean” (Homsey 2004: 49).

The use of unifacial tools declines in the Kirk Stemmed deposits, while stage bifaces, expedient tools, nutting stones, and bone tools (including fishhooks) dominate the technological assemblage (Goldman-Finn and Walker 1994: 110; Sherwood et al. 2004: 547-548).

The representation of mammal remains continues to increase in this component, while the use of birds diminishes (Walker 1998: 138). The recovery of *Chenopodium* declined significantly in the Kirk Stemmed component, and both black walnut and hazelnut use appears to have lessened as well. At the same time, the use of hickory nuts, which are a higher-ranked food resource, appears to have increased dramatically (Carmody 2009: 78, 154; Hollenbach 2005: 164).

Hollenbach (2005: 189-190, 259-262) notes that the plant remains, feature assemblage and larger quantities of shell recovered from the Kirk Stemmed component all suggest an increase in the intensity of site use at the time. In contrast, a drop in the density of lithic debitage indicates a decrease in the intensity of tool manufacture and maintenance activities.

Eva/Morrow Mountain Component (8,300 – 7,400 cal BP)

The function of Dust Cave appears to have changed from an occupation site to a burial locale for at least part of the Eva/Morrow Mountain phase. This shift in use was followed by a period of reuse of the front of the cave for human occupation ca. 7,720 cal BP (Sherwood et al. 2004: 549). Burials were located near the rear of the cave, while features related to residential use of the site were concentrated near the front of the cave where headroom was greater,

representing the only demarcation of activity areas at this time. The number of features recorded in this component increases fourfold compared to the earlier Kirk Stemmed phase, with the feature assemblage being dominated by hearths and fireplace rake-out, which comprised charred materials removed from hearths and prepared clay surfaces. Homsey (2004: 50) suggests that this dramatic increase in the frequency of features may reflect an increase in the intensity of activities being carried out. Prepared clay surfaces are also common in the deposits, and the stacking of these features implies redundancy in the use of space. Redundant internal activity structure, in combination with a refocusing of activity toward the front of the cave may be related to decreasing headroom and a corresponding restriction of the useable living space in the cave (Homsey 2004).

Homsey (2004: 50-51) notes a lack of storage pits at this time, despite strong evidence for nut processing, and suggests that occupants may have been utilizing baskets for storage. She interprets the Eva/Morrow Mountain occupation as representing “use of the site as a special purpose plant extraction camp” (Homsey 2004: 51) during a period of transition from residential to logistical mobility.

In addition to diagnostic projectile points, excavations produced stage bifaces, expedient flake tools, and bone awls, needles, pins, fishhooks and antler tines (Goldman-Finn 1994, Sherwood et al. 2004: 549).

The Eva/Morrow Mountain phase witnessed a slight increase in bird representation, a slight decrease in mammal remains, and a dramatic decrease in the representation of fish. Of the bird remains, a large majority were terrestrial species, including turkey, passenger pigeon, and grackle (Walker 1998: 138). Hickory continued to be represented in the paleoethnobotanical assemblages, while the use of small, edible seeds declined (Carmody 2009: 94).

Benton Component (6,500 – 5,600 cal BP)

Vertical and horizontal living space in the cave had become reduced during the Benton period, concentrating human activity near the front of the cave. The scanty feature assemblage, which included a few hearths, expedient hearths, associated charcoal pits and a single possible nut processing pit, may be indicative of a decrease in the intensity of occupation, perhaps related to a continuing decrease in available headroom in the cave.

In addition to Benton Stemmed projectile points, the deposits also revealed stage reduction bifaces, ground stone pestles, bone awls, needles, fishhooks, projectile points, and antler tines (Goldman-Finn and Walker 1994, Sherwood et al. 2004: 550).

Mammal recovery increases fairly dramatically at this time, and bird representation remains essentially unchanged from the previous period (Walker 1998: 138). Walker (1998: 144) suggests that these trends may be related to changes in the environmental setting that encouraged the Dust Cave population to adapt to restructuring in the local animal populations. By the Benton period, and even earlier in the Middle Archaic, lower-ranked resources (e.g. weedy seeds that offer lower nutritional value in relation to their high processing costs) were eliminated from the forager diet, suggesting an increase in hunter-gatherer foraging efficiency during this time (Carmody 2009: 131). One particularly interesting find from the Benton component was the recovery of a squash rind. Squash and gourds were among the early domesticates in Eastern North America, and may have played a role in the “Container Revolution” (Smith 1986: 29-30), which refers to the invention of stone vessels that foreshadowed the development of ceramic technology.

From this brief overview of the cultural components at Dust Cave, it is clear that several important organizational and cultural shifts occurred in the use of this site from the end of the

Pleistocene into the Middle Holocene. Hunter-gatherer populations, while not solely at the mercy of the natural environment, certainly structure their social, biocultural, subsistence and technological behaviors in response to the opportunities and constraints presented by the natural environment. In order to understand the cultural changes that were occurring through time at Dust Cave it is, therefore, necessary to understand the context, both environmental and archaeological, in which these early hunter-gatherers lived, and to document changes in those environmental circumstances. The remainder of this chapter is devoted to constructing a picture of the geological, climatic, biological and cultural world to which the inhabitants of Dust Cave adapted.

PHYSIOGRAPHIC, ENVIRONMENTAL, AND ARCHAEOLOGICAL CONTEXT OF THE MIDDLE TENNESSEE RIVER VALLEY

The study area is located in an ecologically rich and varied environment, at the intersection of three distinct physiographic regions: the Highland Rim, the Cumberland Plateau, and the Fall Line Hills (Alabama Maps 2016; Figure 2.5). Each of these regions supports its own distinct plant and animal communities. Although the composition of these communities has changed through time, the prehistoric occupants of the region likely enjoyed a similarly rich environment.

Geology and Physiography

The Highland Rim region, within which Dust Cave is located, comprises three distinct sub-zones in northwest Alabama: the Tennessee Valley, Little Mountain and Moulton Valley regions. Each region is underlain by the Mississippian-aged lower Tusculumbia limestone

formation and exhibits its own distinct topography (Alabama Maps 2016b; Figure 2.6). The Tennessee Valley region is characterized by karstic topography that creates gently rolling uplands covered by a network of streams, sinks and springs. The uplands were incised by the Tennessee River, creating a narrow floodplain lined by steep bluffs into which numerous caves have been carved by the flowing groundwater. The river itself contains abundant islands and shoals, all of which provided habitat for approximately 70 species of freshwater mussels, a reliable and easily accessed food resource (Parmalee 1994: 135).

The Tennessee Valley region also contains the most prehistorically significant stone raw material source in the region: the Fort Payne formation. This high quality chert source comprises nodules and bedded deposits underlying the Tusculumbia limestone formation. In their survey of raw material sources in the area of Dust Cave, Johnson and Meeks (1994) noted that, while the tabular deposits may have been quarried to procure raw materials for tool production, the secondary cobble deposits found within the main river channel and in adjacent streams were easily procured and easily modified into tools. My own examination of the Dust Cave lithic assemblage has revealed numerous specimens that exhibit traces of this worn cobble cortex, indicating that prehistoric toolmakers certainly exploited these secondary sources.

The Little Mountain region lies along the southern margin of the river valley and is demarcated by a 30-meter escarpment at the boundary of these two sub-regions. The eponymous “little mountains” were formed by erosion of the underlying Mississippian-aged Hartsell formation sandstone (Harper 1942). A network of streams in the region’s uplands has created a highly dissected topography as well as numerous rockshelters in the hillsides. Stone raw material availability in the Little Mountains is much poorer than in the Tennessee Valley zone, with lower-quality Tuscaloosa gravels representing the only commonly available toolstone.

The Moulton Valley sub-region lies to the south of the Little Mountain region. This zone exhibits minimal relief and is underlain by the Mississippian-aged Bangor limestone formation (Hollenbach 2009: 35). As was the case for the Little Mountain region, this area is stone-poor, with Tuscaloosa gravels being the only locally available raw material for tool production.

To the east and the south of the Highland Rim stretches the Cumberland Plateau. This highly dissected plateau is formed of Pennsylvanian-aged Pottsville sandstone, which has eroded to form rockshelters in the hillsides. Tuscaloosa gravels and fossiliferous Bangor cherts, both lower quality than the blue-grey Fort Payne chert available in the Tennessee Valley region, are the commonly available stone raw materials in the Cumberland Plateau.

The Fall Line Hills, located in the very western portion of northern Alabama, are sharply rising hills formed of Cretaceous sand and gravel deposits known as the Tuscaloosa formation, which overlies both the Bangor limestone and Pottsville sandstone formations. Several major waterways run through the Fall Line Hills, including Bear Creek, Little Bear Creek, and Cedar Creek, as well as their tributary streams. Chert is available in the region both as small pieces of chert gravel from the Tuscaloosa formation and as nodules from the Bangor limestone formation. The Bangor nodules are accessible within the Bear Creek watershed, but they represent a lower-quality material available in smaller packages than the blue-grey Fort Payne chert found in the Tennessee Valley region (Meeks 1998; Randall 2002).

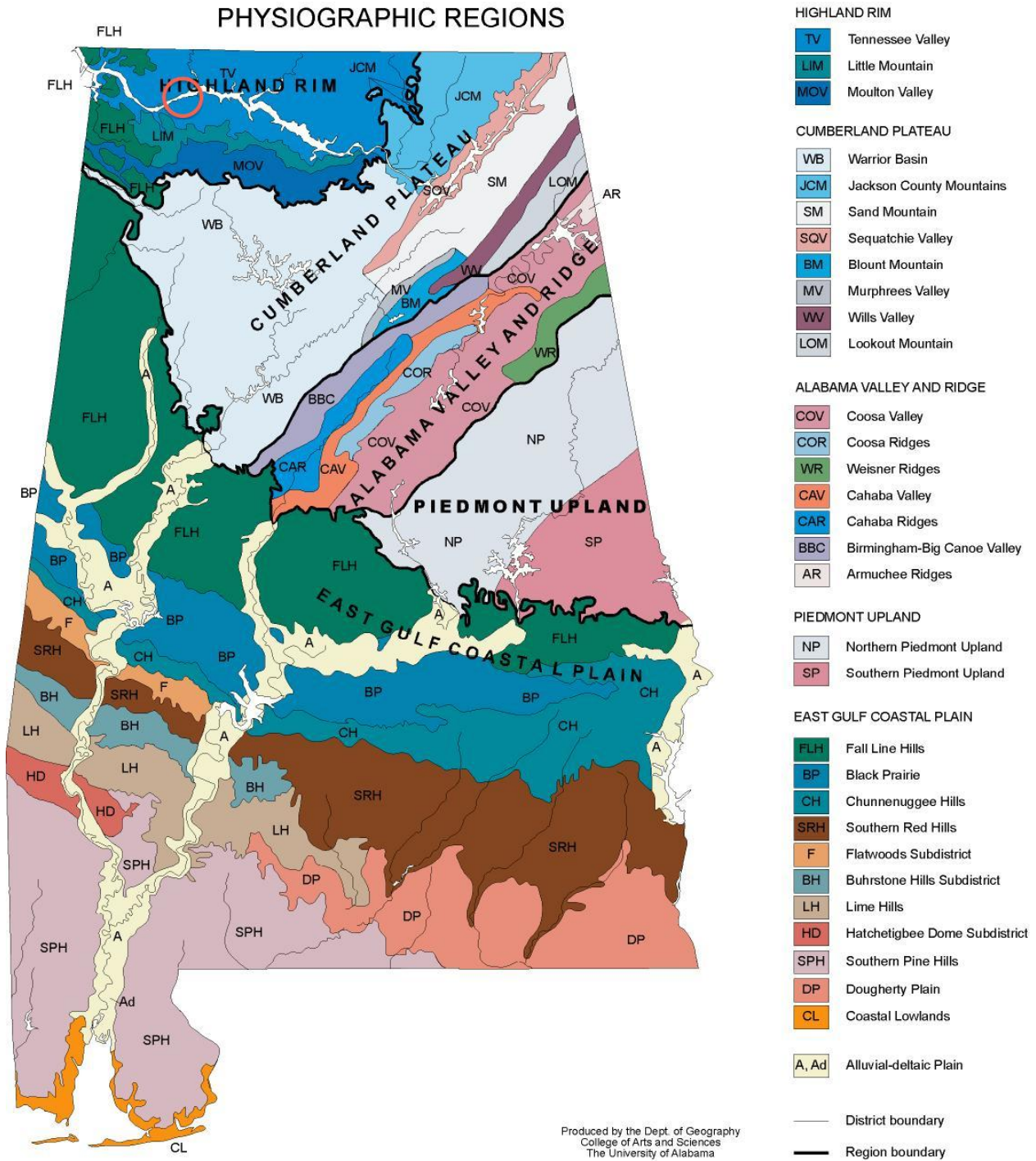


Figure 2.5: Alabama Physiographic Regions (Alabama Maps 2016b). General location of study area/site indicated by red circle.

Modern Ecological Setting

The variable physiography of northwestern Alabama accounts for many of the differences, noted by both historic and modern observers, in the structure of biological communities in the area. As part of her study of foraging behaviors in the Tennessee River Valley, Hollenbach (2005:52-54, 2009:43-48) compiled data from 19th century General Land Office surveys, as well as more modern observations of the region, in order to construct a local model of vegetation distributions and productivity across physiographic regions. The nature of the underlying geology in the regions discussed above plays a large role in determining the structure of the various ecological settings. The zones underlain by sandstone tend to be highly dissected and contain poorer soils, accounting for the prevalence of coniferous trees, while the gently rolling topography and richer soils of the areas underlain by limestone deposits account for the presence of productive oak-hickory forests and the richness and diversity of the animal communities that depend on them.

Within each of the three main physiographic regions we see variability in the biological communities according to the character of the local topography. Bottomlands tend to support the richest forests and the widest array of species, including a variety of aquatic species, fruit trees, and herbaceous/weedy plant taxa. The bottomlands are also home to islands and shoals, which support a variety of mussel species. Uplands and slopes, on the other hand, tend to accommodate more nut-bearing trees.

In addition to the plant and animal resources that are influenced by the nature of the geology and physiography of the area, the nature and quality of available toolstone sources differ across the region. High-quality blue-grey Fort Payne chert, a favorite raw material of the prehistoric toolmakers in the region, was easily accessible to the inhabitants of the Tennessee

Valley physiographic region. Occupants of the surrounding regions were faced with poorer-quality raw material choices that were available in much smaller package sizes.

It is imperative to bear in mind, in the context of this study, that the modern ecological setting likely is not entirely representative of the environment in which Late Paleoindian and Archaic populations lived. However, a consideration of the effects of modern physiography and geology on variability in the contemporary ecological structure may be useful, as argued by Hollenbach (2009: 39):

The fact that the general topography and ecological communities in the project area are largely dictated by local geology, which has not changed significantly over the past 15,000 years, suggests that the *relative differences* among these communities likely held even as climatic conditions changed (emphasis added).

In other words, while the particular composition of biological communities has changed over time in response to climatic shifts, the physical structure of the region likely impacted prehistoric ecological communities in a manner similar to its impacts on the modern ecology.

Paleoclimate and Paleoecology

Beginning approximately 15,000 years ago the world began to feel the grip of the last major period of glaciation loosening. As the Pleistocene drew to a close, global climate amelioration forced the retreat of continental ice sheets and a reorganization of adaptive responses by plant, animal, and human communities. This period of climate change also altered the physical landscape, as new land suitable for occupation opened up under the retreating glaciers, sea levels rose inundating coastlines, and interior river systems in North America began

to stabilize. At this time the relationships among climate, biotic communities, and human hunter-gatherer populations were particularly dynamic.

Climate reconstructions have noted a general trend of global climate amelioration for the past 18,000 years, with the significant and rapid climate changes occurring between 16,000 and 8,000 years ago (Williams et al. 2004: 309). Such environmental shifts have had significant impacts on composition and structure of local biological communities (Webb et al. 1993: 415), as well as on human adaptive and organizational strategies. The discussion of paleoclimatic conditions and paleoecological setting discussed here focuses on reconstructions for eastern North America, with an emphasis on trends in the Southeast in general, as well as northern Alabama in particular.

At the very end of the Pleistocene, in the midst of this general global climatic amelioration, a brief but intense cold reversal known as the Younger Dryas (12,850 – 11,700 cal B.P.; see Anderson et al. 2015: 7-9) was initiated as ice dams burst in the northern portion of the continent, releasing water from glacial Lake Agassiz into the North Atlantic (Teller et al. 2002: 879, Table 1). This influx of cold freshwater is thought to have disrupted the North Atlantic thermohaline system, the “global conveyor belt” that is responsible for circulating warmer water northward from tropical latitudes. This interruption in circulation may have lowered mean annual temperatures by as much as 3°C (Yu and Eicher 1998: 2236). This climatic event had varying effects in different parts of the globe. In the Southeastern United States, winters appear to have been 4 -5 °C cooler than modern temperatures, and summers were approximately 2 °C warmer than at present (Shuman et al. 2002). By the end of the Younger Dryas, temperatures and moisture levels began to increase.

Between approximately 11,400 and 11,200 cal. B.P., another freshwater outburst from glacial Lake Agassiz brought about a brief climatic reversal known as the Preboreal Oscillation. Cooling from this event was less significant than the global temperature drop noted during the Younger Dryas (Teller et al. 2002: 885). By 8,000-9,000 cal B.P., atmospheric moisture levels increased as subtropical air masses began to dominate in the Southeast (Shuman et al. 2002; Shuman et al. 2002), and water levels in the Southeast appear to have increased (Shuman et al. 2002: Figure 2).

One final oscillation, which occurred 8,200 years ago (the “8,200 event”), produced a brief (~200 yr) return to cooler climates that also had a reduced impact compared to the much more dramatic Younger Dryas reversal (Teller et al. 2002: 885). Increased influence of warmer, moist, subtropical air masses in the Southeast produced even more moisture in the region, and by approximately 7,000 cal B.P., annual precipitation had increased.

In the Southeast, following this period of climatic fluctuations, temperatures began to rise once more, with mean January and July temperatures increasing and reaching their maximum during the Holocene Climatic Optimum (8,900 – 5,750 cal yr BP; Anderson et al. 2007: 457). At this time populations seem to have concentrated in hardwood-rich river valleys as they migrated out of the Coastal Plain, where hardwood forests had begun to be replaced by less productive southern pine forests and cypress swamps.

In addition to these broad regional paleoenvironmental reconstructions, analysis of the Dust Cave materials has benefited from modeling of local climatic conditions by Reid Bryson (see Homsey 2004: 316). Approximately 14,000 cal. B.P., mean annual temperatures may have been as low as 12 ° C, with higher winter precipitation and lower summer precipitation. From 14,000 cal. B.P. to approximately 11,000 cal. B.P., mean annual temperatures increased steadily,

with only two downward spikes that likely corresponded to the Younger Dryas and Preboreal Oscillation, respectively. Both events lowered temperatures by approximately 1 ° C, and increased otherwise diminishing winter precipitation. Over the following 2,000 years the temperature and climatic conditions remained relatively stable, but between 8,900 and 7,900 cal. B.P. a rise in mean annual temperature (to 17 ° C) and a decrease in precipitation (to approximately 1300 mm) occurred. In the period following 7,900 cal. B.P., mean annual temperature continued to oscillate, while winter precipitation decreased and summer precipitation increased. These climatic conditions prevailed through to the present time.

Throughout this period of often rapid and dramatic climate change, the fossil record documents equally significant transformations in vegetation and wildlife in eastern North America. The general trend in vegetation change from the end of the Pleistocene into the mid-Holocene has been one of northward movement of taxa in response to the retreat of continental ice sheets and accompanying shifts in temperature and moisture gradients (Webb et al. 1993). Alterations to forest structure are important to consider in the context of this study because “they shape the resources available to hunter-gatherers and the strategies these groups employ to exploit those resources” (Hollenbach 2009: 43). In other words, they are instrumental in structuring patterns of prehistoric human cultural organization.

Broad regional reconstructions of vegetation communities have been produced for eastern North America based on palynological data. While few pollen cores are available for the Southeast in general, and for the Dust Cave region particularly, several have been procured from the region surrounding the study area, including Anderson Pond in eastern Tennessee, B.L. Bigbee Oxbow in eastern Mississippi, Cahaba Pond in eastern Alabama, and Pigeon Marsh and Quicksand in northwestern Georgia. These cores document vegetation change since the last

glacial maximum, including the presence of non-analog biomes that existed during periods of non-analog climate regimes (Delcourt and Delcourt 1981; Overpeck et al. 1992; Williams et al. 2004).

In the era preceding any significant climatic amelioration at the end of the Wisconsin glaciation (ca. 16,500 to 12,500 B.P.), “populations of mesic boreal and cool-temperate deciduous taxa” (Delcourt and Delcourt 1985: 18) dominated forests in eastern North America. These patterns suggest persistence of cool climatic conditions and an increase in precipitation during the growing season. Oak-hickory expansion began at this time in response to an extension of the growing season and an increase in mean annual temperatures. Deciduous trees that previously had existed in refugia began to expand northwards, replacing earlier stands of boreal conifers (e.g., jack pine). At the Pleistocene-Holocene boundary, boreal forest communities gave way to more temperate forest conditions.

As the cool-temperate forests moved northward, other tree species became prevalent in the Southeast. Hornbeam and beech dominated in some areas between 12,000 and 10,200 B.P., with additional substantial representation of hickory, oak, elm and ash. By 10,000 B.P. a mixed coniferous/broadleaf deciduous forest emerged in some areas. Climatic conditions shifted from cool-temperate to warm-temperate (Delcourt and Delcourt 1985: 19).

During the Hypsithermal warming trend that characterized the Mid-Holocene (ca. 8,900 – 5,750 cal yr BP), forest communities around the Appalachian Mountain zone became more regionalized. West of the Appalachians these communities “became species-poor and xeric” (Delcourt and Delcourt 1985: 20). South of the mountains, and in the northern Gulf Coastal Plain, the warm but wet regional climate encouraged the movement of wetland-inhabiting species into central Alabama. Delcourt and Delcourt (1985: 20) note a shift in the dominance of

tree taxa in the Southeastern Evergreen Forest: “Previously dominated by xeric species of oak and hickory, coastal-plain forests became dominated by species of southern pine by 5000 B.P.”

In her study of Late Pleistocene-Early Holocene foraging patterns in the Middle Tennessee River Valley, Hollenbach (2005, 2009) referenced these broad paleoenvironmental reconstructions, in concert with paleontological data, and modern observations of forest structure and productivity, in order to extrapolate the character of local prehistoric biomes, with a specific focus on differences in the productivity of the various topographic and physiographic zones described above. Below, I present a summary of her local environmental reconstruction.

Around 14,000 years ago, prior to the initial occupation of Dust Cave, two main vegetation zones appear to have dominated the surrounding region: deciduous forests in the Fall Line Hills, and non-analog spruce woodlands in the Highland Rim (Hollenbach 2009: 44). The paleontological and zooarchaeological records demonstrate that these non-analog vegetation communities supported some non-analog faunal communities as well. Late Pleistocene faunal assemblages exhibit some distinct differences from modern assemblages as they included a range of now extinct or extirpated species. During initial occupation of the cave approximately 12,900 – 12,000 cal B.P. (Quad/Beaver Lake occupation, and the first 850 years of the Younger Dryas), taxa characteristic of the colder temperatures of the last glacial episode (e.g., spruce, birch, fir, hemlock, alder), began to move northward, becoming a less significant portion of the forest assemblage. The onset of cooler temperatures during the Dalton occupation, which coincided with the later part of the Younger Dryas, is marked in the pollen assemblages by an increase in representation of sedges. In the period following the Younger Dryas (post-11,200 cal B.P.) forests were dominated by mixed hardwood species that are characteristic of cold temperate

forests, and oak, hickory and southern pine forests began to encroach from the south (Hollenbach 2009: 44).

During the onset of the Early Side Notched occupation (11,200 – 10,500 cal B.P.), which represents the first Early Archaic component and corresponds roughly with the beginning of the Holocene, these mixed hardwood forests remained, with oak representing a large proportion of the pollen assemblage, pine increasing slightly, and cold weather taxa (e.g., spruce, birch, ash) decreasing. By the Kirk Corner-Notched period (ca. 10,500 – 9,800 cal B.P.), few trees associated with colder temperatures were represented in the assemblage. By approximately 9,000 years ago (bifurcate tradition ca. 9,800 – 8,600 cal B.P.), northern trees had disappeared from the pollen record, oak remained dominant in the Southeastern forests, and southern pines appear to have retreated slightly to the south.

By the end of the Early Archaic and onset of the Middle Archaic (8,900 – 7,800 cal B.P.), drier conditions appear to have taken hold, as indicated by the increase in sedges and forbs. Oak and hickory also appear to have increased at this time. From approximately 8,000 to 5,000 years ago, the warming and drying trend of the Holocene Climatic Optimum promoted increased stability of the waterways and a decrease in rainfall (Walker 1998: 42). Prairie expanded into the uplands, and the extent of grasslands and cedar glades increased. Climate change during this period of the mid-Holocene is evidenced in the paleontological and zooarchaeological record: “It is during the Hypsithermal that animals such as prairie chickens occur more frequently at sites [in the Midsouth] than during the Early Holocene. In addition, the stabilization of river systems may have increased the reliance on fish and shellfish” (Walker 1998: 47), as indicated by the large quantities of freshwater mussel remains that appear in the archaeological record of sites from this period.

Archaeological Context

The inhabitants of Dust Cave were not alone in adjusting to the climate and environmental fluctuations documented throughout the Pleistocene-Holocene transition. In fact, the Middle Tennessee River Valley boasts one of the densest concentrations of early hunter-gatherer materials in all of North America, including an especially rich record of Paleoindian fluted point finds (Futato 1982). The great density of early hunter-gatherer materials in this region led Anderson and Gillam (2000) to postulate that the Tennessee River valley may represent one of several major staging areas in the initial colonization of eastern North America. From the large numbers of artifacts recovered from much of the span of prehistory in the region, it appears that people arrived in the valley early and stayed.

The archaeological richness of this region may be related in large part to the richness of subsistence and technological resources in the area, and partly to the quantity of archaeological investigations in the area. During the Works Progress Administration era (WPA), the Tennessee Valley Authority (TVA) carried out numerous large-scale archaeological surveys beginning in 1934 as part of their dam construction efforts. Surveys and excavation of many sites in the now inundated reservoirs produced large quantities of archaeological data that continue to be examined by professional archaeologists and students (e.g., Webb and DeJarnette 1942). Beginning in the 1960s, David DeJarnette, along with the Archaeological Research Association of Alabama and the University of Alabama, undertook the testing of rockshelter sites in northwestern Alabama in an effort to refine chronological sequences (DeJarnette 1962). In more recent years, Cultural Resource Management (CRM) projects (e.g., Futato 1983; Oakley and Futato 1975; O'Hear and DeJarnette 1974; Waselkov and Morgan 1983) and a renewed interest in rockshelter and cave archaeology (e.g., Cobb et al. 1995) have served to expand the database

of known archaeological sites even further and have provided important insights into the nature of prehistoric landscape use in the Middle Tennessee River valley.

Drawing on the results of these numerous survey, testing and excavation programs, several researchers (Futato 1995, Goldman-Finn 1994, and Meeks 2001) have worked to tease out site use patterns from the site file data in an effort to understand land use, mobility, and settlement-subsistence systems throughout the prehistory of the region. In her efforts to understand broad-scale foraging behaviors in the Tennessee River Valley, Hollenbach (2005, 2009) also mined the Alabama site file database with an emphasis on understanding land use patterns by cultural phase. Here, I provide a summary of the results of these various studies in order to provide a context for understanding the use of Dust Cave and its position within broader regional settlement regimes.

Middle (Clovis, Cumberland) and Late Paleoindian (Quad) inhabitants of the region exhibited a tendency to locate their sites within the Tennessee Valley physiographic district, and to use non-floodplain topographic locales, such as older levees (Futato 1995: 273; Hollenbach 2009: 69). Meeks (2001 in Hollenbach 2009: 65-67) notes that the earliest occupants of the region demonstrated a preference for sites associated with sinks in the uplands and highlights the frequent reoccupation of sites during the Late Paleoindian Quad period. According to Hollenbach, it is possible that this particular patterning in site use “may be related to the changing morphology of the Tennessee River, which might well have scoured away evidence of early sites (Collins et al. 1994) and/or covered them with alluvial deposits” (2009: 63).

The expansion of Late Paleoindian and Early Archaic populations into other topographic and physiographic regions began with the increased use of floodplain settings during the Late Paleoindian Greenbrier phase. Floodplain use decreased again into the Kirk Corner-Notched and

Bifurcate periods, before rebounding dramatically in the Kirk Stemmed Phase. This trend continues through the Middle Archaic Eva/Morrow Mountain phase and may represent increasing stability of river systems during the Holocene (Hollenbach 2009: 63).

This dramatic shift in land use beginning in the Kirk Stemmed period is also reflected in the expansion of hunter-gatherer populations into other previously sparsely inhabited physiographic provinces. By the Kirk Stemmed and Eva/Morrow Mountain phases, 40% of sites were located in areas outside the Tennessee Valley, including in the Moulton Valley and Cumberland Plateau regions. While the shift toward the use of floodplain settings may reflect a response to increasing stability of river systems, it is likely that the use of these other physiographic regions instead “hints at more complex shifts in landscape use by the close of the Early Archaic period and subsequent Middle Archaic” (Hollenbach 2009: 65).

A consideration of the frequency of sites through time demonstrates relatively little fluctuation until the Early Side Notched and Kirk Corner-Notched periods when site numbers increase dramatically. An equally notable decrease occurred during the Bifurcate phase, and by the Eva/Morrow Mountain period, site numbers had returned to earlier Paleoindian values (Hollenbach 2009: 65-67).

Similar trends are observed in the frequency of site reoccupation, which held constant at approximately 40% throughout the Paleoindian and Early Archaic periods but increased to 88% in the Bifurcate period. The Bifurcate period corresponds roughly with the 8.2 ka cooling event, and Meeks (Driskell et al. 2012) has suggested that this dramatic trend may represent a conservative approach to landscape use by populations suffering settlement-subsistence stresses brought on by this climatic oscillation. In fact, based on similarities in site placement, it is quite possible that Bifurcate peoples experienced similar stresses compared to those that affected the

Late Pleistocene occupants of the region. By the Kirk Stemmed and Eva/Morrow Mountain phases, site reoccupation had declined.

In summary, the overall number of sites and the number of sites in physiographic regions other than the Tennessee Valley increased through time, despite a reversal in both these trends during the Bifurcate period. A major reorganization of landscape use and settlement is suggested in the Kirk Stemmed and Eva/Morrow Mountain phases, which saw little reoccupation of sites, a focus on floodplain settings, and an increased use of regions outside the Tennessee Valley.

Landscape use appears to have remained relatively constant between the Paleoindian and Early Archaic periods, but with the climate changes that characterized much of the Holocene, and the corresponding responses by plant and animal communities, populations began to exploit settings that previously had witnessed little occupation. The 8.2 ka event, characterized by an abrupt decrease in global temperatures, may have been responsible for the reversals noted during the Bifurcate phase. Following this brief cold period, the warmer and drier conditions during the Kirk Stemmed period appear to have encouraged major settlement reorganization. This period marks the disappearance of unifacial blades from toolkits, an intensification of hickory nut use, and a greater emphasis on the exploitation of animals from closed habitats (Hollenbach 2009: 67). Each of these patterns marks a distinct break in the continuity of trends noted from the Paleoindian through much of the Early Archaic in the Middle Tennessee River Valley.

Throughout this chapter, I have attempted to illustrate the important connection between changes in past climate regimes and subsequent responses by local plant and animal communities. I have also considered, briefly, broad changes in the ways prehistoric human populations organized themselves in the context of these shifting environmental circumstances. In the following chapter, I present an overview of the theoretical framework I will use in guiding

my interpretation of the ways in which changes in the lithic technology may be related to these broader patterns of environmental and land use change. Hollenbach (2005, 2009) and Carmody (2009) have both used theories from Behavioral Ecology to explain prehistoric foraging strategies and how these strategies served to facilitate adaptation to the changing environmental conditions of the Late Pleistocene through Middle Holocene in the Tennessee River Valley. I present an overview of their findings before discussing the Organization of Technology, a theoretical framework that will guide my own interpretation of the changes in technological decisions that facilitated the accomplishment of the settlement-subsistence goals of the Dust Cave population.

CHAPTER 3: THEORETICAL FRAMEWORK

From the brief overview of cultural components presented in Chapter 2, several trends are apparent through time in the nature of technological and subsistence behaviors. Some of these trends appear conflicting, as Hollenbach (2005: 262) notes:

On the one hand, the assemblages at Dust Cave demonstrate continuity in the kinds of activities performed at the site: collection and processing of nuts and edible seeds, general use of fruits, hunting, fishing, butchering, hide preparation, and manufacture of bone and stone tools. On the other hand, they suggest subtle shifts in the use of habitats and intensity of particular activities.

Briefly, there is an apparent decrease in the intensity of tool manufacture and maintenance through time and a decrease in the exploitation of animal resources relative to plant foods. We also note diachronic shifts in the nature of the technological assemblage. First, the standardized blade technology upon which much of the Late Paleoindian technology was based disappeared in the Early Archaic. Second, bifaces became increasingly important, especially in the Early Side-Notched period. And, third, the formal unifacial technology that characterized the Late Paleoindian and Early Side Notched toolkits virtually disappeared by the end of the Early Archaic, while minimally modified flake tools increased in relation to the representation of more formal flake implements.

With these preliminary results in mind, the overarching goal of this dissertation is to provide an interpretation of the technological changes from the Late Pleistocene through Middle Holocene, in relation to changes noted in the character of the environment, and in corresponding strategies of environmental exploitation. Given that the questions we ask in archaeology, and the particular theoretical perspectives we use in approaching the answers to those questions, guide

our data collection strategies, the following section presents a discussion of the conceptual frameworks enlisted in this analysis and interpretation.

Human Behavioral Ecology

The research presented here on the archaeological materials from Dust Cave benefits from over 20 years of prior research. The superior preservation of organic remains at Dust Cave produced an impressive dataset that has provided the context for interpretations of such topics as site formation (e.g., Sherwood 2001), internal site structure (e.g., Homsey 2004), and subsistence behaviors (Carmody 2009; Hollenbach 2005, 2009; Walker 1998). This particular analysis is concerned with the research that has been conducted on the subsistence and mobility strategies employed by the hunter-gatherer population at Dust Cave. Technological behaviors are intimately tied to subsistence and mobility concerns, as technologies provide a means of extracting energy from the environment, are conditioned by mobility patterns, and both influence and are influenced by the interactions between people and their natural and social environments. Designing and producing an appropriate technology involves making decisions in the context of other social and cultural concerns such that those technological behaviors facilitate, rather than obstruct, the accomplishment of other socioeconomic goals. The connection between technology and the rest of the cultural system is elaborated in the discussion of technological organization, below. First, though, the ways in which changes in foraging patterns at Dust Cave have been approached and analyzed are discussed.

Hollenbach (2005, 2009) and Carmody (2009) have both successfully interpreted changing subsistence trends at Dust Cave using models derived from Evolutionary and Behavioral Ecology, specifically Central Place Foraging Theory and the Diet Breadth Model.

When applied to human populations, these models are concerned with understanding the decisions hunter-gatherers make in order to maximize their reproductive success within particular social and environmental contexts (Kelly 1995; Smith and Winterhalder 1992; Winterhalder and Smith 1992). These approaches have provided insight into the changing nature of subsistence pursuits, environmental exploitation, mobility patterns, and even gendered patterns in the division of labor. Each of these represents a set of cultural changes that may have necessitated or been influenced by the shifts witnessed in the technological system. Before discussing the theoretical framework employed in the interpretation of the technological changes at Dust Cave, I consider the use of Behavioral Ecology in archaeology, and in Hollenbach's (2005, 2009) and Carmody's (2009) models of foraging behaviors from Dust Cave. Their models provide much of the context for the interpretations of the technological patterns at the site presented here.

Behavioral Ecology in Archaeology

Ecological approaches have dominated much of the research on hunter-gatherer populations since the mid-twentieth century (Kelly 1995: 6). While hunter-gatherer societies are not solely the product of their environments, it is clear that their adaptive strategies are strongly influenced by the opportunities and constraints presented by the natural environment, and much of the variability seen in those strategies may be attributed to differences in environmental context (Kelly 1995: 35). Forager populations "gain their livelihood fully or predominantly by some combination of gathering, collecting, hunting, fishing, trapping or scavenging the resources available in the plant and animal communities around them. By this definition, key properties of this form of economy are ecological in nature" (Winterhalder 2001: 12). Studies of extant and

historically known hunter-gatherer groups around the world have demonstrated great variability in these societies that presumably is a pale reflection of the even greater variation that may have existed among the more numerous prehistoric forager populations. Anthropologists and archaeologists have recorded variability in dietary composition, mobility structures, the function and prevalence of exchange systems, land tenure systems, group size and structure, division of labor, etc. In recent years, anthropologists have become interested in assessing this cultural variability in terms of the diversity of environments in which foragers live (e.g., see Kelly 1995, Binford 2001).

An interest in the relationships of hunter-gatherers to their environments has a deep history in anthropology, stretching back to Kroeber's (1939), Wissler's (1926), and Mason's (1896) notions of the Culture Area, and more recently to the introduction of Evolutionary and Behavioral Ecology into hunter-gatherer anthropology. By the mid-20th century, Julian Steward (1955) had introduced into anthropological studies the paradigm of Cultural Ecology, through which "the relationships between society, technology, and environment" (Kelly 1995: 42) could be interpreted and the origins of culture traits could be explained. He proposed the notion of the "culture core," defined as a set of behaviors that facilitate the capture of energy from the environment (Kelly 1995: 42). All other aspects of society were viewed as developing from this "core." Steward suggested that this paradigm would explain how human societies adapted to the variable environments they inhabited. While providing an important explanatory perspective on hunter-gatherer adaptations, Steward's approach fell short by neglecting to define an objective measure of "success" in adaptation and by emphasizing the maintenance of socio-cultural equilibrium, rather than seeking to explain culture change.

In the 1970s, as a reaction to these shortcomings, anthropologists began to adopt a set of research paradigms collectively termed Evolutionary or Behavioral Ecology. Evolutionary Ecology is the study of the relationships of organisms to one another and to their environments from an evolutionary perspective, taking into consideration the evolutionary histories of species and their interactions (Pianka 1978). Behavioral Ecology adds to this perspective a consideration of the evolutionary basis for animal behaviors. When applied to the study of human populations, Human Behavioral Ecology invokes neo-Darwinian evolutionary principles in the study of human behaviors, with the view that evolutionary processes, especially natural selection, operate to determine the frequency and occurrence of particular behavioral variants in human societies. This paradigm has come to be viewed by many anthropologists as “a useful context in which to understand variation among hunter-gatherers” (Kelly 1995: 37).

Surovell (2009: 6) has argued that Behavioral Ecology should be distinguished from the broader umbrella of Evolutionary Ecology because, (a) despite being rooted in evolutionary principles, it does not consider evolutionary origins or changes in gene frequencies and (b) because studies rooted in Behavioral Ecology tend to be synchronic and, therefore, are not truly “evolutionary,” despite their consideration of adaptive success. In this study, I use the term Human Behavioral Ecology, as I am concerned with interpreting the reasons for the presence of and changes in particular human cultural behaviors. I am more optimistic than Surovell, though, that this approach can be used to track and interpret the reasons for behavioral/cultural change through time.

To understand how Behavioral Ecology serves to explain human cultural adaptive strategies, it is important to review the tenets of biological evolutionary theory. Evolution is a process of biological change in organisms that occurs as a result of “differential survivorship

and/or reproduction of particular phenotypes” (Kelly 1995: 51) that are produced through the interaction of the genotype with the environment. This process requires (a) genetic variability, which can be produced through mutation, genetic drift, and recombination, and (b) a mechanism for transmission of traits across generations (DNA). One view postulates that selection operates on variability in the genetic composition of *individuals* within a population and contributes to the survival of those individuals whose phenotypes confer the greatest reproductive advantage within the particular environmental context. A competing hypothesis, and one that may be appropriate for understanding adaptation in the highly social human species, considers the adaptive capacity of *groups*. Group selection theory suggests that groups can compete in a similar manner to individuals. Wilson and Sober (1994) suggested that groups can be vehicles for selection. In human groups, the existence of social norms to which group members are expected to conform may overshadow competition and selection at the individual level, shifting selection to the group instead.

The translation of these biological concepts into characteristics of human behavior can be difficult (a) because behavior is not determined entirely by genetics, (b) there is not a tangible cultural equivalent to DNA that operates as the mechanism of transmission for cultural patterns across generations, and (c) cultural variability is less frequently introduced through random or non-goal-directed processes. Nonetheless, it may be argued that we can identify some elements of cultural systems that parallel the required conditions for biological evolution, specifically variation among individuals, as well as a mechanism for transmission.

First, a strong case can be made for the existence of individual variation in human behavior, both between individuals and between populations. No two people/groups are entirely alike, biologically or culturally. Within societies that establish social or cultural norms,

individuals or sub-groups will tend to interpret behavioral “rules” in their own particular ways, based on their own experiences and world-views. These differing perspectives may lead people to engage in socially or culturally prescribed behaviors in slightly different ways from one another. Variation in behavior can be seen among different social sub-groups that are divided according to age, gender, or status. Disparities in the skill levels of individuals can also lead to differences in the execution of particular behaviors. Human ingenuity, invention, experimentation, and accidental discoveries can also lead to the introduction of behavioral variants. While behavioral variation, unlike biological or genetic variation, generally is not created through random processes (e.g., mutation), its existence suggests a cultural parallel upon which natural selection can operate, as certain behaviors may be more or less suited to efficient cultural adaptation in a given context.

Second, while there may not be a “behavior” molecule that transmits cultural or behavioral information across generations, there is a process by which the cultural repertoire is disseminated. Humans are not born with cultural knowledge, but instead gain it through the processes of learning and enculturation. Parents teach their children, and members of peer groups teach each other. In hunter-gatherer societies, the youngest members of the groups are taught how to hunt, how to procure and process food, how to construct shelters, how to fashion tools, and are educated about group beliefs and ideology. With cultural variation present, and a social method of transmission, Human Behavioral Ecologists argue that natural selection may operate on this variation, in particular natural and social environmental contexts, in order to select for behavioral strategies that confer the greatest fitness.

In the case of biological evolution, natural selection operates on the genetic variation within a population and selects for those individuals or groups whose biological or behavioral

traits confer greater fitness to the individual or group within a particular environmental context. Over time, allele frequencies shift, as individuals or groups who possess these traits are more likely to survive and pass their genes to the succeeding generation. In the study of cultural evolution, “success” is not measured solely through the achievement of biological goals (i.e. reproduction), but also cultural ones. Behavioral Ecologists suggest that natural selection operates in a similar fashion on the range of human behavioral variants within particular natural and social environmental contexts, producing a set of behaviors that serve to maximize individuals’ opportunities to achieve these various goals. Kelly (1995: 51) suggests that those behaviors “that are linked to greater fitness in a particular natural and social environment and that are heritable (through culture or genes) should, therefore, tend to become more prevalent in a population.”

One key difference between the evolution of biological and cultural traits is that the selective process operating on variants in cultural behaviors takes on a somewhat “unnatural” character as human actors actively make choices among a known set of culturally transmitted alternatives. Kelly (1995: 51) argues that humans make rational choices among these alternatives as they subconsciously weigh the consequences of their reproductive and cultural actions. While humans are not necessarily conscious of the reproductive effects of their decisions, it is argued that evolutionary forces are nonetheless responsible for humans’ innate ability to evaluate their decisions and the resultant consequences (see Cronk 1991; Kelly 1995). This emphasis on decision-making is perhaps the most important element of Human Behavioral Ecology, which “is fundamentally about *problem solving*” (Surovell 2009: 6, emphasis added)

All organisms, including humans, face a similar set of basic problems, namely the need to meet essential nutritional and physiological requirements, to maximize mating opportunities, and

to produce offspring. For humans, these goals are met through biological, behavioral, and cultural adaptations. In studying human responses to these problems, Behavioral Ecologists rely on the assumption of *optimization*. Such studies tend to “focus on (1) the behavior of individuals making decisions about (2) the available set of behavioral options using (3) some currency (energy, measured as calories, dominates current studies) that permits the costs and benefits of each option to be evaluated, within (4) a set of constraints that determines the options and their benefits” (Kelly 1995: 53). Behaviors are considered “optimal” if the time and energy costs required for their execution are minimized while the benefits are maximized, thereby leading to an increase in fitness (Winterhalder 1981: 15).

This notion of optimization is central to studies of Human Behavioral Ecology. In hunter-gatherer research, evaluation of “optimality” has tended to focus on aspects of individuals’ foraging behaviors (e.g., foraging time, diet selection, food sharing, etc.), as the outcomes of foraging are linked directly to the survival of individuals and their offspring (Kelly 1995: 54). Following from evolutionary theory, it is often assumed that the goal of individuals should be to forage optimally, specifically to “maximize the net *rate* of food intake” (Kelly 1995: 54), while simultaneously minimizing elements such as the time spent or risk incurred during foraging. Foraging efficiency is often viewed as representing a proxy measure of fitness. Kelly (1995: 54) argues that optimization is a particularly significant concern to hunter-gatherer populations under the following conditions: (1) if particular nutrients are in short supply; (2) if available foraging time is limited; (3) if foraging behaviors pose certain risks to the forager; (4) or if surplus food can be used to enhance reproductive fitness.

This approach has come under scrutiny by researchers who argue that hunter-gatherer populations do not calculate caloric value and energy expenditure and might not be as concerned

with “efficiency” as we are in industrialized societies. Others have responded to these critiques, suggesting that foragers likely learn “rules of thumb” (e.g., larger package sizes – of foods and stone – are likely to be more profitable) to assist them in making foraging decisions (Hollenbach 2009: 16-17, Winterhalder 2001). These rules of thumb, which are inherited through cultural transmission, are subject to selective forces that “weed out” inefficient or sub-optimal alternatives. Efficiency and optimization in foraging is of at least some importance to foragers who must consider how to allocate time to various activities, including gathering food, nurturing of offspring, producing and maintaining tools, and meeting social obligations (Kelly 1995: 55). Many subsistence activities, especially for foragers living in more temperate latitudes, are constrained by temporal limits (e.g., seasonal availability of resources, or the need to factor in travel time between disparate resource patches). Optimality and efficiency therefore become a significant concern as foragers make decisions regarding how to acquire enough food within given time limits and still have time to spare for other non-subsistence-related tasks and obligations.

As archaeologists, we rely on various optimization models in our attempts to understand the foraging decisions of extinct populations. Most of the models we employ in archaeological studies “take the form of cost-benefit analyses using microeconomic models and detailed studies of available resources” (Hollenbach 2009: 17). Modeling behavior requires specifying a goal (i.e., the intent of the agent, the currency being maximized or minimized) and a decision variable (i.e., the aspect of behavior being modified in order to meet that goal). Resulting behaviors are considered relative to the constraints or limits posed by the environment and by the biological limits of the organism. These models, in association with the optimization assumption, provide Human Behavioral Ecologists with “a conceptual framework with which to understand the

relationships between the abundance and distribution of food resources, decisions about how to allocate time to foraging and other activities...and the effect these have on the transmission of cultural information” (Kelly 1995: 63). In sum, Behavioral Ecology represents a promising approach for understanding the dynamic relationship between environment and culture and provides a means of understanding both change and continuity in prehistoric societies. The following section presents a discussion of the application of two models from Behavioral Ecology, namely Central Place Foraging theory (Hollenbach 2005, 2009) and the Diet Breadth model (Carmody 2005) to the interpretation of foraging patterns in the Middle Tennessee Valley in general and at Dust Cave specifically.

INTERPRETING SUBSISTENCE TRENDS

Central Place Foraging at Dust Cave

In her study of the botanical remains from Dust Cave and three other rockshelter sites in northwestern Alabama, Hollenbach (2005, 2009) draws on two concepts from the broader field of Evolutionary/Behavioral Ecology: the division of labor and Central Place Foraging (CPF) theory. While she does not make explicit use of specific models of the division of labor, Hollenbach uses these models to shape her analysis of early foragers’ gathering activities (2009: 19).

A consideration of the ethnographic and ethnohistoric literature on subsistence activities reveals a nearly universal division of labor along gender lines, with women generally performing the majority of gathering tasks, and men engaging in most of the hunting (Hollenbach 2009: 19). While various approaches have been proposed to facilitate an understanding of this rather

standardized division of labor, the models that Hollenbach discusses – Conflict and Complementarity Models – “place the biological differences between women and men at the base of the division of labor” (2009: 23). The Conflict Model centers on differences in female and male strategies for achieving reproductive success, in the evolutionary sense, while the Complementarity Model focuses on differences in the reproductive lives of females and males. Both models view the division of labor as being rooted in the evolutionary history of humans, and the models suggest “different foraging decisions for women and men based on their reproductive differences” (Hollenbach 2009: 24). It is not unreasonable, therefore, to expect that the human populations that inhabited Dust Cave during the Late Paleoindian and Archaic periods would have exhibited a similar division of labor.

Hollenbach (2005, 2009) interprets the paleoethnobotanical assemblages from four rockshelter sites in northwestern Alabama within the framework of this assumption, arguing that these botanical assemblages represent primarily the subsistence decisions of women, as well as children and the elderly (Hollenbach 2009: 24). Rather than subsistence pursuits and settlement organization being structured around the likely male-centered hunting forays, as archaeologists have often postulated, Hollenbach suggests that the nature of hunter-gatherer economic organizational strategies in the Southeast may have been governed by the foraging decisions of women, based on their particular reproductive roles and requirements.

In order to explore “why people occupied these four rockshelter sites, how they may have organized their movements between these and other open-air sites through the seasons of a year, and how gathering may have influenced these movements” (Hollenbach 2009: 18-19), Hollenbach applies a model of Central Place Foraging to the interpretation of her datasets. Central Place Foraging is a model within the larger theoretical paradigm of

Evolutionary/Behavioral Ecology in which foragers are assumed to transport foodstuffs to a “central place” (i.e. a centralized camp from which foraging expeditions are organized), and it is assumed that foragers should make subsistence decisions that are geared toward maximizing the rate of energy return to that central place (Hollenbach 2009: 24). Within the framework of Central Place Foraging theory, we assume that foragers will locate their central places near important resources, particularly those resources that are predictable in occurrence, abundant, and fairly easily procured. In contrast to mobile, often elusive, and generally riskier animal prey, plants are stable (immobile), predictable (gatherers can easily familiarize themselves with seasonally and yearly cycles), and not very risky or difficult to procure (their procurement requires a minimal investment of energy and poses minimal physical risks to the gatherer). Plant foods also provide important vitamins and minerals and can compensate for dietary gaps if a hunt is unsuccessful. Plant foods therefore form a very important part of some hunter-gatherer diets despite the fact that they provide comparatively low caloric return rates when considered alongside certain animal resources.

In light of the apparent importance of botanical resources, Hollenbach suggests that “site locations and mobility patterns are organized around the seasonal and spatial availability of plant foods and other gathered resources. More specifically, [she hypothesizes] that early foragers chose their base camps so that women, children, and the elderly could exploit gathered foods residually, while these groups exploited other resources, both animal and raw materials, logistically” (Hollenbach 2009: 27). She tests this hypothesis by considering (1) the plant and animal remains from the four rockshelter sites including Dust Cave, (2) where in the local landscape those food resources would have been available, and (3) “the costs that the regional topography imposes on foragers as they procure various subsistence resources and return with

their proceeds to a base camp” (Hollenbach 2009: 69). In other words, she considers the energy returns gained from given resources and compares them to the energy expended in their pursuit and transport within the given landscape. She also considers differences in availability and yield by season and how these differences would have affected foraging and mobility strategies.

Hollenbach’s consideration of return rates for various plant and animal taxa, as well as stone raw materials, revealed the following patterns:

Faunal Data

Hunter-gatherers are likely to travel farther to obtain larger prey, such as deer and turkey. They also are more likely to exploit fish and mussels at greater distances from the occupation site, especially if the mussels are processed in the field. Smaller animals, like squirrel and waterfowl, will tend to be exploited only if they are available in close proximity to the site.

Botanical Data

In her consideration of plant taxa from the rockshelter sites, Hollenbach divided the plants into two broad categories, based on their caloric values and handling costs: (1) fruits and greens, vs. (2) nuts. She determines that fruits are not likely to be procured at great distances from the site, but over shorter transport distances they produce high return rates, on par with those of some animal resources. Seeds entail higher processing costs but are still relatively profitable over larger distances. In other words, foragers were likely to travel greater distances to procure seeds.

Hickory nuts produced the highest return rates among the plant foods considered. Hazelnut and black walnut produced very low return rates, which may seem perplexing at first.

The low return rates are likely related to their higher processing and search costs, rather than to their local availability.

Stone Raw Materials

Distance to the source area appears to be the governing factor in determining transport costs for stone raw materials. Stone could be processed at the outcrops in order to reduce unusable bulk and maximize transport efficiency (see Metcalfe and Barlow 1992). Large pieces of stone might have been reduced to transportable early stage bifaces that could be used as portable raw material sources (i.e. a source for tool blanks), large chopping tools, or as preforms for the production of bifacial implements (Kelly 1988). Hollenbach suggests that early foragers in northwestern Alabama likely gathered toolstone through an embedded procurement strategy: “Because there is no caloric return associated with obtaining chert, and because other chert sources were locally available throughout the region, it is likely that foragers obtained blue-grey Fort Payne chert during subsistence-related forays to the river” (2009: 93). Because alternative sources of stone were available throughout the region, we must consider what the advantages might have been of targeting the higher-quality blue-grey Fort Payne chert instead of simply making use of lower-quality, locally available materials. If it appears that using a high-quality stone source conferred particular advantages (e.g., the ability to make larger tools, or ones that could be successively resharpened), then the need for high quality raw materials, rather than plant foods, might have been the driving force behind settlement mobility and subsistence scheduling (Hollenbach 2009: 93).

From her discussion of the return rates of these various resources, Hollenbach concludes that “The most important feature of a resource that affects its return rate on a given landscape is

the handling cost associated with its use” (2009: 93-94). Foragers will tend to travel farther to obtain most animal resources, as well as nuts and seeds, but will only exploit items like fish, mussels, fruits and greens – all of which have lower processing costs – if they are available in close proximity to the site. This generalization persists unless there are seasonal and spatial differences in availability.

Seasonal Foraging Round in Northwestern Alabama

With these potential sources of variability in mind, Hollenbach (2005, 2009) suggests a seasonal round for these early foragers living in northwestern Alabama. She argues that foragers would have resided in creek bottoms in the spring, exploiting spawning fish and migratory waterfowl, as well as populations of deer and turkey. In the floodplains, where weedy plant species thrive, foragers could also have collected edible greens. Smaller hunting parties, perhaps even just pairs of hunters, could have pursued deer while larger groups targeted abundant fish populations.

In the summer, foragers may have continued to inhabit the creek bottoms where they could have exploited fruits such as mulberries, as well as aquatic resources including fish, mussels and turtles. Forays could have been made into the uplands to procure grapes and other fruits and in order to monitor these fruits as well as ripening mast resources.

It is likely that, in the early autumn, foraging populations would have been attracted to the slope and upland forests where deer and turkeys were feeding on the ripening hickory nuts and acorns. Hunters, who may have operated in groups of two or more, could have preyed easily on these animals that were in prime condition at this time of year. Sizeable work groups likely were sent out during the early autumn to collect hickory nuts and acorns. These task groups may

also have collected hazelnuts and black walnuts as they were encountered, but based on their low return rates it is improbable that these resources were targeted in the same way as the more productive oak and hickory trees.

Hollenbach (2005, 2009) posits that foragers would have returned to creek bottoms in the late autumn and early winter in order to procure any lingering edible and weedy seeds. Other game may have been attracted to these same resources, affording hunters an opportunity to target animals that were otherwise more elusive at this time of year.

During the height of winter, when stores would have become depleted, foragers may have turned to harvesting whatever seeds and fruits persisted, perhaps opportunistically and with significantly lower-than-ideal return rates. Hollenbach suggests that

In the Late Paleoindian period, when winters may have brought significant snows to the area, hunters likely took advantage of yarding deer, perhaps in larger hunting groups. Foraging groups might then have moved into the uplands and slopes, particularly of the Tennessee Valley, where the conifers of the spruce woodlands might have provided shelter and food, serving as a winter yarding area for deer (2009: 95).

A Model of Settlement-Subsistence at Dust Cave

The subsistence data from Dust Cave certainly seem to support the general model that Hollenbach (2005, 2009) developed for northwestern Alabama. The particulars of the subsistence assemblage at this site allow refinement and testing of the model in the examination of the site lithic assemblage herein and tailoring of the model to chronicle the changes through time in the specific nature of site use at Dust Cave.

Both the plant and animal remains from the site can provide insight into the season(s) of occupation at Dust Cave. A fall occupation is indicated by the presence of various nut taxa, while

fruits may have been exploited from mid-summer into the fall. Hollenbach (2009) suggests that fruits may have been collected in order to supplement the diet prior to the nut harvest, or they may have been procured opportunistically while foragers were targeting nut resources in the autumn. Weedy seeds may have been used from the summer through fall, and may even have persisted into winter. It is possible that the greens produced by these same weedy species may have been targeted in the spring.

Occupation of the site during the fall or winter is suggested by the recovery of a deer frontal bone with an antler still attached to it, and by the presence of remains of migratory passenger pigeons. Use of migratory waterfowl during the Late Paleoindian period suggests occupation of the site either during the spring or the fall. Walker (1998) indicates that the recovery of sucker, which move into smaller tributaries from the main river channel to spawn, likely indicates use of Dust Cave in the spring. While the majority of the faunal data suggest a possible spring and/or fall occupation, the exploitation of mussels could have allowed use of the site at any time during the year.

While a fair degree of continuity is noted in the range of plant and animal taxa recovered from the site, closer examination of the data reveals variability through time in the intensity with which various taxa were used. Hollenbach (2009: 226) notes that, while the plant assemblages from the various periods of occupation at Dust Cave tend to be characterized by the presence of nutshell, this general pattern masks more subtle shifts in plant use over time. A general increase in plant remains throughout the occupation sequence indicates more intensive site use, “whether through more frequent visits, longer stays, or increased activity during those stays” (Hollenbach 2009: 226). Hickory nut use, in particular, increases dramatically from the early occupations to the Kirk Stemmed period (see discussion of Carmody’s [2009] study, below). While nut use

intensifies, the exploitation of weedy seed plants such as *Chenopodium* appears to decline. Little change is noted in the use of fruits, with the exception that mulberries appear less commonly by the Kirk Stemmed period.

It appears that, by the Kirk Stemmed occupation, the inhabitants of Dust Cave were making less use of resources that thrive in open/edge settings and instead were targeting forest resources (e.g., increased use of nuts and mammals; decrease in use of waterfowl). The reasons for this shift may include climatic changes associated with the onset of the Hypsithermal warming trend and/or changing cultural practices (Hollenbach 2009: 226-227).

One other interesting trend to note is the apparent stability through time in the use of aquatic resources. But, as Hollenbach indicates, “This relative stability masks a significant increase in exploitation of fish after the late Paleoindian, as well as a decrease in the use of waterfowl. Reliance on aquatic habitats is also indicated by the recovery of mussels, which appears to increase in the Kirk Stemmed component” (2009: 227). So, while the degree of focus on aquatic habitats seems to remain fairly consistent through this period of occupation, the particular nature of aquatic habitat use appears to change, likely in response to shifts in environmental conditions at the time.¹

Preliminary consideration of the stone tool data also points to a fair degree of consistency in the activities being performed at the site. The range of tools recovered (hafted and non-hafted bifaces, scrapers, drills, gravers, intentionally and unintentionally modified flakes) indicates that

¹ The Kirk Stemmed period corresponds roughly with the onset of the Holocene Climatic Optimum (Hypsithermal). Migratory waterfowl may have become less available as sinkholes in the uplands began to dry up. During this same period, increased global temperatures resulted in stabilization of sea levels as continental ice sheets melted. The higher sea levels enabled stabilization of the river systems and provided ideal conditions for the expansion of mussel shoals (see Smith 1986: 22-24; Steponaitis 1986: 372).

hunting, butchering, hide preparation, and the production of bone and wooden tools occurred throughout the Late Paleoindian and Early Archaic. Initial microwear analyses confirm these interpretations (Meeks 1994). The recovery of debitage from the various components also indicates that stone tool manufacture was occurring on site. Despite the consistency in the activities performed, there are several important shifts noted in the lithic data. First, the use of large blades and specialized, formal unifacial tools, which were common in the Late Paleoindian assemblage, drops off dramatically after the Early Side Notched period. Secondly, the density of lithic debitage recovered from both the screened samples and the flotation samples does not remain consistent and “indicates significant differences through time in the intensity of tool manufacture and maintenance” (Hollenbach 2009: 228). The greatest density is seen in the Early Side Notched, a pattern that contrasts with interpretations derived from other classes of data that suggest more intensive site use in the Kirk Stemmed period.

While the particular activities that occurred at the site seem to remain quite consistent through time (i.e., collection and processing of nuts and edible seeds, gathering fruits, hunting, fishing, butchering, hide preparation, and tool manufacture and maintenance), there are “subtle shifts in the use of habitats and intensity of particular activities” (Hollenbach 2009: 229). There appears to be an increased use of closed habitats by the Kirk Stemmed period, as indicated by the use of a different range of faunal resources, an increased focus on hickory, and a distinct decrease in the exploitation of edible seeds. The tool data suggest less emphasis on tool manufacture and maintenance, while the faunal data demonstrate a reduced reliance on animal resources relative to plant resources.

It appears, then, that the collection and processing of hickory nuts had become of primary importance to the Kirk Stemmed occupants of Dust Cave. This increased focus on hickory may

be a response to diminished processing costs (adoption of stone boiling technology for processing), or increased availability of these nuts in the local environment. There are no compelling environmental data, however, to suggest such an increase in hickory stands during the Kirk Stemmed. It may be that periodicity of masting episodes decreased in response to the warmer temperatures that accompanied the onset of the Hypsithermal. An increase in the use of forest animal species in the Kirk Stemmed deposits seems to support the possibility of expansion or increased productivity of the forest environments.

It is also possible that the *manner* of site occupation changed at this time. Hollenbach suggests that, “Given their more intensive occupation of the site, [the occupants of Dust Cave] may have disposed their stone and bone waste in different manners than previous groups” (2009: 231). The decrease in the density of lithic debitage in the Kirk Stemmed component could, therefore, represent “deep cleaning” of the site (i.e., sweeping of the living surfaces; Homsey 2004: 49) during longer or more intensive periods of occupation, rather than a decline in the importance of tool manufacture. Examination of the talus slope outside the cave did not reveal much debris, though, which may be an indicator that the inhabitants of the cave were not simply disposing of their garbage beyond the cave. It has been suggested, though, that the talus was scoured at some point in the past, although the precise timing is not known (Driskell, personal communication). It is possible, therefore, that debris from this period may have been removed.

Hollenbach concludes that the true nature of the changing site occupation at Dust Cave may represent elements of more than one of the abovementioned scenarios. Regardless of the particular nature of the changes in site use, it is apparent that “the placement of Dust Cave within hunter-gatherers’ economic, and likely social, landscapes changed significantly by the close of the Early Archaic” (Hollenbach 2009: 231). It is precisely this shift in the position occupied by

Dust Cave in the social and economic landscape of the Middle Archaic that Stephen Carmody evaluates in his 2009 thesis.

Application of the Diet Breadth Model to the Middle Archaic Remains from Dust Cave

Carmody (2009) expands on Hollenbach's study (2005, 2009) by considering the Middle Archaic botanical remains from the Eva/Morrow Mountain and Benton components. His goal is to assess changes in mobility and subsistence strategies employed by these latest occupants of the site. By comparing his findings to the results of earlier analyses, he considers cultural adaptations to changing environmental conditions and a changing cultural landscape.

Carmody (2009) applies another model from Evolutionary Ecology, the Diet Breadth Model, to his study of the Middle Archaic botanical remains. The Diet Breadth Model falls under the umbrella of Optimal Foraging Theory (OFT) within Evolutionary Ecology and provides a means of understanding the dietary choices made by foragers. In OFT, foragers are assumed to make subsistence decisions that maximize the net rate of energy return relative to energy expended in searching for, procuring and processing food resources. The Diet Breadth Model helps to explain the *specific* resources that are targeted in pursuit of this goal of maximization. It explains what food items will be selected or excluded when encountered; the range of items included in the diet; and what items will be added to or dropped from the diet as environmental conditions change.

Carmody (2009) reviews patterns seen in the paleoethnobotanical data from the Middle Archaic components and compares them to data from the earlier occupation periods. He argues that the Middle Archaic data are suggestive of an increase in foraging efficiency. He notes an

overall increase in plant density through time until the Benton period, when a slight decrease may have been related to a reduction in available living space in the cave.

While an overall increase in plant density is noted, not all taxa conform to this pattern. Hickory is noted in all sample types from all periods, and the frequency of hickory remains increases through time. Use of acorn increases after the Late Paleoindian period, peaks in the Early Side Notched, but declines through the Middle Archaic. The use of black walnut and hazelnut is sporadic throughout the occupations, a trend that may be related to higher processing costs or to the nature of the required collection strategies. Exploitation of fruits spiked in the Early Side Notched and Kirk Stemmed periods, then declined in the Middle Archaic. Small edible seeds were more abundant in earlier deposits, but decreased in frequency in the Middle Archaic.

Carmody (2009) applies the Diet Breadth Model to his analysis of botanical remains from Dust Cave in order to assess whether the botanical data confirm an increase in foraging efficiency during the Middle Archaic. He approaches this problem by considering energy gained from these foods (in kCal) vs. energy expended in their procurement. He then ranks those resources according to their final return rates. Fruits and nuts are both considered to be high-ranked resources. Fruits are high in calories without entailing high procurement or processing costs. Nuts provide protein, fats, and amino acids and, if processed using a smash-and-boil method, yield edible nutmeats with little effort. Hickory nuts and, to a slightly lesser degree, acorns provide especially high return rates. Black walnut and hazelnut, on the other hand, are ranked much lower because of their handling costs and less concentrated availability (i.e. high search costs). Edible seeds and greens are similarly low-ranked resources.

These observations of the Dust Cave botanical assemblage demonstrate that, through time, hunter-gatherer populations in the region made greater use of plant foods that provided higher returns without significant processing costs, and began to ignore those foods with high processing costs and comparatively low return rates. This pattern certainly seems to suggest an increase in foraging efficiency during the Middle Archaic. Ames (1985) has argued that increased foraging efficiency and intensification should be signaled by an emphasis on certain resources over others. At Dust Cave, this preferred resource in the Middle Archaic components appears to have been hickory nuts.

This increase in foraging efficiency may be explained either by reference to environmental shifts or technological advances. While there do not appear to be significant changes through time in the technologies associated with nut processing, some significant environmental changes have been recorded that might help to explain this emphasis on mast resources in the Middle Archaic. First, pollen studies have revealed an increase in oak and hickory during the mid-Holocene Hypsithermal warming (Delcourt 1979; Delcourt and Delcourt 1985; Delcourt et al. 1983; Prentice et al. 1991). This period of climatic warming and drying produced conditions that were ideal for the expansion of open oak-hickory forests, which may help to explain the increased density of nutshell in the Middle Archaic deposits. Warmer temperatures may also have decreased the periodicity of masting episodes, which are cycles in “bumper crop” production. Changes in forest canopy dynamics, though, may represent the most significant impact of the Hypsithermal on the availability of subsistence resources. In open/edge habitats, such as those that appear to have expanded during the Middle Archaic/Hypsithermal, hickories can produce much larger quantities of nuts per tree. The species poor and xeric forests

that appear to have existed at this time likely would have been host to highly productive hickory trees (Delcourt 1979; Delcourt and Delcourt 1985: 20; Munson 1986).

Carmody (2009) argues that examination of the patterns seen in other classes of data from Dust Cave reflect changing use of the landscape by foragers who were responding to these environmental shifts. He reviews the data from the human burials, as well as the lithic, faunal and feature assemblages.

Burials

The site produced more than two dozen human burials, most of which were concentrated in the Eva/Morrow Mountain phase (Davis 2004). This relatively dense concentration of human remains at the site from this period suggests use of the cave as a burial locale for at least a part of its occupation. The emergence of cemetery sites has some significant implications for understanding human use of the landscape: “Placing ancestors in a fixed location is believed to have been a social act carried out in order to establish certain groups’ access and rights to natural resources, and [to] express their relationships to the land” (Carmody 2009: 148). A concentration of burials like the one seen at Dust Cave may represent territorial marking or territorial control, especially in regions where important resources were located.

Lithics

Previous research on the lithic assemblage from Dust Cave (Meeks 1994; Randall 2001, 2003) has recorded a decrease in lithic density, an increase in the importance of bifacial technology, and a decrease in the diversity of raw material use through time. Carmody (2009) notes a decrease in the frequency of small flakes recovered from the flotation samples, which

suggests that later stage tool production and maintenance activities may have become less important in the later occupations. He proposes that this pattern may indicate a decreased emphasis on hunting, a suggestion that seems to be supported by trends in the faunal data (i.e. an overall decrease in the density of faunal remains), as well as a decrease in the frequency of hide scrapers, and an increase in the frequency of nutshell relative to lithics (i.e. an increased focus on plant collection compared to other subsistence activities). An apparently greater emphasis on bifacial technology in the Middle Archaic may reflect an increased need for a “flexible” technology, which Carmody (2009) suggests may offer an advantage to logistically mobile groups.

The previously noted decrease in the diversity of raw material types represented in the Dust Cave lithic assemblage may be related to greater territorial circumscription and a shift to logistical mobility in the Middle Archaic. Territorial circumscription, which itself may have resulted from a reorganization of the local resource structure in combination with an increase in human population density, would have limited toolmakers’ access to particular “exotic” raw material sources. The very close proximity of Dust Cave to a source of high-quality blue-grey Fort Payne chert would have allowed the inhabitants of Dust Cave, who appeared to be occupying the site as a specialized nut-processing station in the Middle Archaic, to exploit this source readily and to produce and use their technology in a more expedient fashion.

Faunal Remains

Examination of the faunal data from Dust Cave reveal a decrease in the importance of fish and waterfowl during the mid-Holocene, corresponding to a reduction in marshy areas during the Hypsithermal. The increase in mammal remains from the Middle Archaic deposits

corresponds to expansion of more open forests and ecotone environments, which are attractive to species like white tailed deer and rabbit. The increased use of deer by Middle Archaic hunters may have been a response to denser populations of deer feeding on the larger quantities of acorns that were being produced as xeric oak-hickory forests expanded and replaced mesic forests.

Features

Lastly, consideration of the feature assemblage from Dust Cave reveals an increase in the number of features during the Eva/Morrow Mountain phase but a decrease in their diversity. Both frequency and diversity decrease in the Benton phase, perhaps reflecting a reduction in available living space more than a change in site use. Carmody (2009) posits that the emphasis on features related to nut processing in the Middle Archaic deposits indicates a shift from the use of Dust Cave as a residential base camp during the earlier occupation periods, to a logistical, task-specific, nut-gathering and processing locale.

Logistical Mobility in the Middle Archaic

Taken together, Carmody (2009) argues that these patterns are all quite suggestive of a shift from residential mobility to a logistical mobility strategy. Referencing Kenneth Ames (1991), Carmody argues that logistical mobility will be indicated by increased redundancy in the archaeological record of particular sites “as the environment increasingly becomes divided between groups on the landscape...Through time the archaeological record of Dust Cave reflects this level of redundancy, witnessed in the analysis of feature functions, botanical remains, faunal remains, and lithics recovered from the site” (Carmody 2009: 153).

ORGANIZATIONAL BEHAVIOR AND LITHIC TECHNOLOGY

The Behavioral Ecology analyses of subsistence and settlement practices, discussed above, demonstrate much continuity through time in these behaviors, with certain notable exceptions. These exceptions include: the Late Paleoindian focus on avifauna, specifically waterfowl, that decreases in later occupations; an increase in the use of hickory nuts through time, with a peak in the Kirk Stemmed period; fluctuations in the use of weedy seeds; and fluctuations in the use of various habitat types. Apart from these few differences, there is great continuity in the range of subsistence items that were pursued and in the character of site use, with the possible exception of the Late Paleoindian occupation.

In contrast to the consistent nature of settlement and subsistence pursuits, preliminary examinations of the lithic data (e.g., Meeks 1994; Randall 2002; Sherwood et al. 2004), have demonstrated some significant technological changes through time. First, the specialized blades that were common in the Late Paleoindian deposits disappeared in the succeeding Early Archaic period. Second, a dramatic increase in the importance of bifaces was noted in the Kirk Stemmed deposits. Third, the formal unifaces that were common in the earliest occupation levels were abandoned by the end of the Early Archaic. Fourth, the use of non-formal and more expediently produced tools increases after the Early Archaic. Finally, shifts are seen in the intensity of tool manufacture throughout the history of occupation at the site, peaking in the Early Side Notched period and decreasing throughout the Middle Archaic.

This contradiction between subsistence and technological patterns is somewhat perplexing because, if we view technology as a mediator between people and their environments that serves, in large part, to facilitate energy extraction from the environment (i.e., to facilitate subsistence pursuits), then we might expect consistency in subsistence pursuits to be reflected in

technological consistency. To address the reasons for this disparity and, more generally, to consider change and continuity in technology, especially in relation to the nature of settlement-subsistence systems and the environmental context, I draw on the theoretical approach known as the Organization of Technology (or Technological Organization). This framework, which exhibits strong similarities to many of the concerns addressed by Human Behavioral Ecology, seeks to understand the ways in which technology articulates with other aspects of prehistoric lifeways and how technological decisions influence and are influenced by other organizational concerns (Carr 1994; Nelson 1991). My goal is to integrate the technological data into this framework to understand how shifts in technological behavior articulate with changes in foraging behaviors.

Organization of Technology: Background

The history of lithic analysis closely parallels developments in the broader field of archaeology, having progressed from an initial classificatory-descriptive period, through the development of taxonomic systems and the definition of relative chronological reconstructions. In the post-WWII period, the field of lithic analysis witnessed the introduction of a variety of technological advances that culminated in the development of several important methods, including experimental flintknapping, refitting, microscopic use wear analysis and residue analysis (Collins 1975). These developments in methods, while enabling significant advances in the field, produced quantities of very particularistic data that restricted “the scope of the conclusions that could be generalized from the information” (Odell 1996: 2) and masked the anthropological relevance of these lithic studies. This particularism incited a backlash in the early 1980s and prompted many lithic analysts to develop a concern with integrating data and

theory in order to incorporate lithic studies more fully into interpretations of prehistoric behavioral systems (Nelson 1991: 57; Odell 1996: 3). This approach emerged in concert with the newly pioneered forager-collector model (Binford 1980) and with the introduction of Optimal Foraging models into hunter-gatherer studies (e.g., Bettinger 1980; Hill and Hawkes 1983;). The lithic theoretical approach that developed in North American archaeology at this time was known as the Organization of Technology. This framework draws on perspectives from a variety of other disciplines, including engineering, and exhibits strong ties to the French *chaîne opératoire* perspective (Lemonnier 1992; Leroi-Gourhan 1964; Schlienger 1994) as well as to the tenets of Behavioral Ecology. At its most basic, this theoretical paradigm provides a means to understand the articulation between technology and broad-scale behavioral patterns in society. It relates “artifacts, such as chipped stone tools and debitage, to a variety of economic and social parameters that allow sound inferences concerning the dynamics of past cultures” (Carr 1994: 1). I discuss the Organization of Technology and its conception below.

The Organization of Technology was outlined in detail in Margaret Nelson’s seminal 1991 article. Before I consider this approach, though, it is important to consider what ‘organization’ means in anthropological studies. Organization in prehistoric behaviors has become a central concern in hunter-gatherer studies in recent decades (Nelson 1991: 51). ‘Organization’ refers to the structure of behaviors relative to one another and to broader environmental patterns and social, cultural, and economic concerns. For example, *settlement organization* refers to the ways in which people organize or place various sites (including residences, extraction sites, special-activity loci) on the landscape, and how populations move among those site types within the context of certain environmental parameters (e.g., spatial or

temporal availability of resources), and to meet various social requirements (e.g., the need to maintain mating, social, information, or exchange networks; social aggregations; etc.).

An organizational perspective on technology encourages archaeologists to consider technology not just as “tools” or static artifacts that are the by-products of human production behavior. Instead, technology is seen as a dynamic set of behaviors that involve conscious planning and strategizing from the outset of the manufacturing process, through to the eventual incorporation of implements into the archaeological record. These behaviors are executed in order to solve adaptive problems posed by the natural and social environments. Choice of technological strategies is conditioned by the nature of the environmental context, favoring the selection and organization of particular strategies over others (Carr 1994: 1). Natural environmental considerations that impact technological design include: technological and subsistence resource predictability, distribution, periodicity, productivity and mobility; size and patchiness of technological and subsistence resource areas; and natural hazards. Social environmental concerns include: the need to acquire mates; the size of the social group that can be supported by available resources in a region; the development and maintenance of social networks; and the need for information exchange.

Among the various iterations of the definition of Technological Organization, Nelson’s (1991: 57) still stands out for its simplicity and comprehensiveness:

This is the study of the selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance. Studies of the organization of technology consider economic and social variables that influence those strategies.

This emphasis on the dynamic role played by technologies in cultural systems, which pervades all definitions of the Organization of Technology, draws inspiration from the *chaîne*

opératoire, a notion coined by the French anthropologist André Leroi-Gourhan in his 1964 monograph *Le Geste et la Parole*. The *chaîne opératoire* translates as ‘operational chain’ or ‘operational sequence’ and “refers to the range of processes by which naturally occurring raw materials are selected, shaped and transformed into usable cultural products” (Renfrew and Bahn 2013: 25). These processes leave material traces that are detectable in the archaeological record (e.g., the by-products of production behaviors) and that can be interpreted to reconstruct the steps in the production of material culture. Beyond simply allowing the documentation of material processes, though, the *chaîne opératoire* facilitates the reconstruction of the dynamic relationships among these processes, the equipment involved in their execution, the timing and spatial occurrence of the various production stages, etc. From a consideration of these dynamic relationships, proponents of the *chaîne* suggest that it is possible to approach the social, ecological, and even the cognitive contexts in which the production of prehistoric technology, and simultaneous construction of social/cultural meaning, occurs. This approach encourages consideration of the manufacturing process, which, when situated in its spatial and temporal context, can enlighten lithic analysts about the dynamics of past natural and social landscape use.

The ability of archaeologists to enter the minds of prehistoric populations is debatable, especially when we study ephemeral hunter-gatherer populations or groups who lived in the deep past. Interpreting the social meanings attached to past materials and behaviors is a significant challenge. The Organization of Technology iteration of the ideas presented in the *chaîne opératoire* may, therefore, be of more utility when studying the lithic remains of prehistoric foragers, as Technological Organization places less emphasis on the construction of meaning in the production of material culture, and more on the production sequences and life histories of tools.

Beyond simply documenting stages of production, the nature of tool use, and the state of tools upon discard, the Organization of Technology approach seeks to understand the adaptive problems being faced by a population and the decisions that are made in the execution of technological strategies that are designed to meet these adaptive challenges. Through this approach, we recognize that there can be many tools and techniques employed to execute a task satisfactorily. The question of importance, then, is: what causes one option to be selected over any other?

Technical needs as well as the social and economic contexts of production narrow the range of potential technological solutions (Perlès 1992: 25). To interpret technical needs, the Organization of Technology approach references Design Theory, various incarnations of which inform disciplines such as engineering (see Bleed 1986), architecture (Alexander 1964) and art (Pye 1968). Design Theory provides a means for conceptualizing the design process, for evaluating the superiority of design alternatives in various contexts, and for explaining the forms technologies take under various circumstances. Enabling an evaluation of the appropriateness of various design alternatives is one way that the Organization of Technology can inform archaeologists about the role of technologies in the adaptive strategies of prehistoric populations.

The applicability of Design Theory to studies of prehistoric Technological Organization lies in its recognition that technology is used to solve adaptive problems, and that toolmakers actively make choices among technological alternatives, within various contexts that determine, or at the very least place limits on, the suitability of the different alternatives. These choices are seen being made at the level of raw material selection, as well as during the process modifying raw materials into desired implements (Horsfall 1987: 333). In the case of archaeological studies, like the one presented in this dissertation, technology is viewed as being used to solve *adaptive*

problems that center on the ways that people articulate with their natural, technological, and social environments (Carr 1994: 1; Torrence 1989a, 1989b).

Design Theory recognizes a tension between design *constraints* and the incorporation of all design *considerations*. Design constraints are the aspects of acceptable or adequate task performance, or the limits imposed on the technology by the requirements of the task to be performed and the context in which tools will be utilized. Examples of design constraints include: the requirement that a tool must meet a certain performance level; the need for raw materials to be available and accessible without incurring excessive costs; and “the economics of various production and use alternatives, including relative use-lives and repair costs” (Hayden et al. 1996: 10). Among mobile hunter-gatherer populations, other important constraints on technological design include: portability (Bleed 1986; Nelson 1991); time available for procurement and processing activities (e.g., Tomka 2001; Torrence 1989a, 1989b); and risk mitigation (Hayden et al. 1996).

Design considerations, on the other hand, are the decisions that tool producers make regarding elements of the technology to emphasize – such as reliability, maintainability, flexibility, portability, etc. – within the context of the given design constraints. For example, should a technology be reliable or maintainable? Do the tools require a long use-life, or will a short use-life suffice? These decisions affect tool production, use, maintenance, and even discard, and they facilitate the achievement of both technological and non-technological goals in the given environmental, social, technological, or economic context.

Producers of the technology are concerned with what design elements (i.e., design considerations) to emphasize in order to meet *most optimally* the requirements of adequate task performance (i.e., design constraints) necessitated by the demands of the external constraints that

pose adaptive problems. The phrase *most optimally* is emphasized because there is an inherent imbalance between the ability to maximize acceptable task performance and the ability to incorporate *all* design considerations. For example, it generally is impossible to produce a technology that is both durable (i.e., will stand up to prolonged use) and inexpensive (i.e., uses cheap materials and/or labor). Similarly, it is not always possible to produce a reliable technology, in the sense of an unlimited supply of tools, if a mobile population must use those tools at locations removed from their preferred raw material sources. Toolmakers facing this problem might choose to utilize lower-quality, locally available materials, but this compromise entails sacrificing tool quality and producing a technology that might not be as durable or as easily reworked. Another alternative might be for tool producers to manufacture large quantities of implements at “gearing-up” stations, but this solution requires sacrificing a degree of portability that is of great concern to highly mobile populations. Alternatively, the group might opt for more residential stability. In a patchy or highly seasonal environment, though, the hunter-gatherer group might run the risk of facing subsistence shortfalls if they choose to remain close to preferred raw material source locations.

From the two examples discussed above, it should be apparent that toolmakers are faced with a constant series of decisions to be made, and that not all design considerations can be incorporated fully or in equal measure in the execution of technological designs. Certain design considerations will have to be overlooked in favor of others that are deemed to be more important for the completion of a given task. Returning to the above example, mobile hunter-gatherers living in a patchy or seasonal environment, who cannot afford to remain sedentary for fear of not meeting subsistence needs, might be forced to rely on the production of a higher-quality technology, one that can be used to meet the sometimes unpredictable requirements of a

mobile lifestyle and that is more certain to remain usable throughout procurement and processing episodes away from the raw material source. A strategy such as this may necessitate the use of higher quality cherts (e.g., available in larger package sizes, fine internal crystal structure) that can be reshaped effectively and that can endure successive resharpening episodes while continuing to produce a usable edge (e.g., Goodyear 1979). High-quality cryptocrystalline materials are not ubiquitous; therefore toolmakers using this strategy might be required to produce larger tools that can undergo successive resharpening episodes and/or larger quantities of tools to replace those broken during use while away from the raw material source. Both options require sacrificing a certain degree of portability, but it is a sacrifice that could mean the difference between eating and starving.

A list of priorities is, therefore, developed as part of the design process. Compromises are constantly made in the quest for solutions to adaptive problems. Such solutions may never be perfect or entirely optimal (Jochim 1989: 107-108; Nelson 1991: 59-61; Schiffer and McGuire 1992: 23; Torrence 1989b: 58). Instead, toolmakers must work to achieve the most satisfactory solution within context of the given environmental constraints. Toolmakers work to improve the effectiveness of technologies in given contexts and renegotiate effective solutions as the context changes.

Flintknapping is a learned behavior that entails cultural transmission of the sum total of technological knowledge within a group. Certain culturally proscribed and acceptable technological schemes will therefore be available from which toolmakers can choose appropriate solutions to adaptive problems. Toolmakers assess the technological needs (design constraints) and select appropriate solutions from among known operational sequences, emphasizing useful technological elements in response to design considerations such as time constraints, raw

material availability, the need for conservation, mobility strategies and the consequent need for portability, etc. Certain strategies, or recurring sets of decisions, will be employed for as long as they are deemed useful, in other words for as long as they facilitate achievement of adaptive goals that are conditioned by the nature of the environment with which toolmakers and tool users interact.

In archaeological studies that rely on the Organization of Technology, lithic analysts generally seek an understanding of the adaptive problems being faced by prehistoric communities and how a search for solutions to those adaptive problems contributed to the material form of the technology, as seen in the archaeological record. Margaret Nelson explains that,

For archaeologists, identification of the adaptive problems comes from assessing environmental conditions as they affect or are affected by human use of that environment. The problems are obstacles to achieving maximum return on investments of time and energy (Nelson 1991: 60).

The levels of analysis possible in Technological Organization are displayed in Figure 3.1.

Carr and Bradbury (2011) explain that the lowest level of the diagram, which includes artifact form and artifact distribution, can be used to understand technological design and the distribution of activities that revolve around the technology. Examining technological design and activity distribution enables lithic analysts to interpret technological decisions, as well as social and economic strategies. At the top level of the diagram we see environmental conditions, illustrating the strong influence that the environment plays in determining appropriate social and economic tactics. These levels of analysis are ordered on the basis of their degree of connection to material implications (Nelson 1991: 53). Analysis can proceed from the top or bottom of this scheme in order to approach an understanding of social and economic strategies. Characteristics

of the environment provide clues to the range of subsistence options and potential economic pursuits. The possible social and economic strategies, such as movement patterns and seasonal patterns of exploitation, as well as the potential technological responses that might be expected, can be interpreted from an understanding of environmental conditions.

Alternatively, a consideration of patterning in the artifact assemblage, specifically in the form and distribution of artifacts, can be used to interpret activities in which those artifacts were being used. Recognition of certain design elements that point to technological strategies executed in response to the interactions of humans with the environment can also provide a means to interpret the social and economic strategies being pursued.

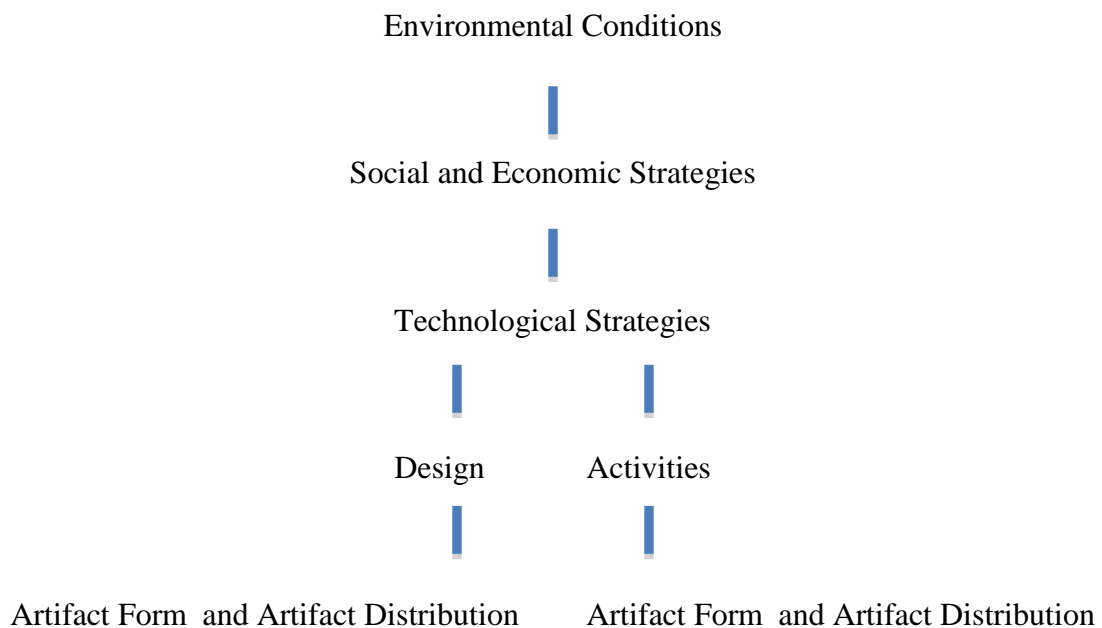


Figure 3.1: Levels of Analysis in Technological Organization (adapted from Nelson 1991)

Regardless of the particular method used (i.e., starting at the level of the environment, or at the level of patterning in artifact form and distribution), studies of Technological Organization aim to approach the social and economic strategies pursued by prehistoric populations, especially the ways in which those strategies reflect the adaptive behaviors of humans living within specific social and environmental contexts. In the case of Dust Cave, we can approach this problem from both the “top” and the “bottom” of the Technological Organization interpretive scheme. Environmental reconstructions are available at both the regional (e.g., Delcourt and Delcourt 1987) and local (Bryson 1999a, 1999b in Homsey 2004) levels. Thanks to the paleoethnobotanical analysis by Hollenbach (2005, 2009) and Carmody (2009), and the faunal analysis by Walker (1998), we have a good record of the subsistence resources that were available at various times, and a sense of their distributions within the local landscape. Detailed lithic data, including the work presented here, provide usable information on the form and distribution of artifacts at the site. Design choices can, therefore, be considered in conjunction with an understanding of the changing nature of the environment in order to approach an appreciation of the technological, social, and economic strategies employed by the inhabitants of Dust Cave.

The environmental context and the nature of the subsistence economy have already been discussed. Below is a discussion of some of the major technological design considerations that reveal decision-making in the process of technological strategizing. The ways in which these decisions are manifested materially and under what conditions we might expect certain selections to be made are discussed. This discussion provides the basis for understanding how we draw the links between artifact attributes, including their form and distribution, and the technological strategies that are fundamental to our interpretations of social and economic adaptive behaviors.

Design Considerations in the Organization of Technology

Curation

Technological plans can be identified in the lithic record through material traces that signal choices among a variety of broad strategies of Technological Organization. The earliest discussions of Technological Organization, as well as many subsequent considerations, have focused on what have frequently been viewed as two opposing organizational strategies: curation and expediency. Nelson (1991) adds to this dichotomy a third strategy that she calls “opportunistic” behavior. Nelson emphasizes that the concepts of curation, expediency, and opportunistic technological behaviors

do not delimit a class of artifact or a type of assemblage. They identify the kinds of plans for facilitating human uses of the environment that can be carried out in a variety of ways and are responsive to a variety of conditions. Artifact forms and assemblage composition are the *consequences* of different ways of implementing curation and expediency (1991: 61).

The curated/expedient dichotomy was introduced into the archaeological vernacular in the work of Lewis Binford (1973, 1977, 1979), whose ethnoarchaeological studies among the Nunamiut contributed a great deal to archaeological understandings of hunter-gatherer technological behaviors. Binford (1973, 1979) viewed curation, in a very basic sense, as a means of producing an efficient and reliable technology by extracting the maximum utility from a tool by transporting it from site to site. He argued that curated technologies tend to be manufactured in advance of use, are maintained throughout and between periods of use, are transported between sites, are effective for performing a variety of tasks, and are often recycled. Curated tools also tend to exhibit consistency in design, according to their function, and are often produced from higher-quality raw materials. These items are also frequently hafted. Binford viewed curation as a technological response characteristic of logistically mobile societies who

would have needed to anticipate future technological needs for the times when their resource extraction activities took them away from preferred lithic raw material sources.

Expedient technologies, on the other hand, have been defined as those produced in response to immediate, unanticipated needs. According to Binford, toolmakers who opt for an expedient technology tend to make use of immediately available raw materials, relying on raw material caches, the transformation of existing tools, lost or discarded tools scavenged from previously occupied sites, or locally available raw materials, which are often of lower quality than their preferred sources. Expedient tools exhibit no particular consistency in their design. Binford argues that these tools may have been used by residually mobile populations, especially if raw materials could be cached at frequently reused sites.

Other researchers quickly adopted the curated/expedient dichotomy as a simple way to characterize prehistoric technological assemblages and systems. For a concept that has remained so fundamental to discussions of Technological Organization, though, it has become horribly muddled over the last several decades. “Curation” now encompasses a variety of often contradictory definitions, some of which “have confused technological strategy with design” (Nelson 1991: 63). The concept has been redefined and even shunned by various researchers.

In response to Binford’s original definition, Torrence (1983) proposed that curation be defined simply as production of tools in advance of use. She viewed this strategy as an efficient reaction to time stress that arises as a result of scheduling conflicts between “mutually disruptive activities” (Bamforth 1986: 39) and as a result of limits on time available to carry out particular activities (e.g., time limits on the procurement of seasonally restricted resources). Preparation of tools can be carried out during periods of down-time during the execution of other tasks.

Torrence argues, therefore, that time stress in other activities promotes an increased emphasis on

the production of tools in advance of use during periods of “low stress,” when technological production would not have interfered with the pursuit of other goals. Toolkits would then be ready for use during “high stress” periods.

Bamforth (1986) presented a critique of these earlier views of curation, in which he recognized that most archaeologists attempted to explain curation behavior through reference to “efficiency.” His primary critique lay in the ambiguous use of the concept of “efficiency”: “curation is a complex activity and...its component parts are efficient in different ways” (Bamforth 1986: 38). Traditionally, anthropological studies have viewed efficiency as the maximization of time or energy expended in carrying out a given task (e.g., subsistence pursuits, settlement strategies). Binford considered curation to be efficient, with efficiency in this case referring to “the utility derived from a tool as expressed in terms of the energy expended in its manufacture” (1973: 250). In Binford’s view, efficiency in manufacture is necessary under certain settlement systems, which also require efficiency. In particular, he suggests that curation and a logistical mobility strategy should occur together, as “both are organizational responses to conditions in which improving efficiency would pay off” (Binford 1977: 35). Torrence (1983) viewed curation as an “efficient” response to conditions of time stress. Production in advance of use would mean that those implements would be ready for use during critical periods, and precious time would not have to be diverted to tool manufacture during the course of carrying out other crucial tasks.

Bamforth (1986: 39) critiqued both of these perspectives, first arguing that neither Binford nor Torrence considered the varied behavioral responses that can be invoked as part of a curation strategy. In considering Binford’s approach, Bamforth (1986) argued that Binford provided no reason to assume that his elements of curated technologies always occur together.

Different aspects of curation may prove adaptive under different circumstances, and so “no single measure of technological efficiency can be universally applied to explain them” (Bamforth 1986: 39). Bamforth regarded Torrence’s singular view of technological efficiency as being too limiting, ignoring the variety of other possible effects of curation behavior (Bamforth 1986: 39).

Bamforth argues that, “Ultimately, technology is structured by the requirements of an activity or set of activities that constrain variation in all aspects of tool *manufacture* and *use*. An efficient technology fulfills these requirements with a minimum effort” (1986: 39; emphasis added). To understand curation, Bamforth argues we must consider efficiency in the scheduling of activities, in the procurement of materials and production of technology, *and* in the context of tool use. While these prior definitions emphasized efficiency in the production end of the technological spectrum, Bamforth argued that efficiency in the context of use was equally important to contemplate. In considering maintenance and recycling of tools, Binford (1977, 1979) made at least passing reference to efficiency in the use context, but Bamforth argues that these behaviors, rather than reflecting a curation strategy influenced by either the nature of the settlement system (Binford 1979) or time stress (Torrence 1983), might be more closely linked to the availability of raw materials. To illustrate this point, Bamforth (1986: 39-40) suggests that pausing in the midst of performing a task in order to resharpen a dulled tool, or to recycle a spent implement, might not be as efficient as simply picking up another sharp flake in order to complete the task. *However*, if raw materials are not immediately available to produce replacement implements, then such alternatives to maintenance and recycling might not be the lowest-cost strategies. Transportation of tools between sites, another commonly cited facet of “curation behavior,” may also be related more to raw material availability. Bamforth’s second major critique of earlier approaches to curation, therefore, lay in their lack of attention to local

patterns of stone raw material availability (1986: 40). Assessment of technological organization in general and issues of curation in particular must, therefore, be conducted with reference to both “overall systemic organization” (e.g., settlement organization), and the nature of local conditions (e.g., raw material availability and distribution) (Bamforth 1986: 40).

Bamforth’s attempt to clarify the curation concept was met with disapproval by some lithic technologists who saw his contributions as muddling the concept even further. Odell (1996) attempted yet another analysis and clarification of the curation concept, taking the perspective that “Stone tool curation is a concept employed to explain certain aspects of prehistoric hunter-gatherer behavior, and its effect on lithic assemblages can be similar to that of responses to lithic raw material scarcity” (Odell 1996: 51). He recognized that there continued to be confusion over what, exactly, a “curation” strategy involves, how it relates to mobility organization, and how it is manifested archaeologically. He addressed the five main components of curation advanced by Binford (1979) and referenced by Bamforth (1986): production in advance of use, design for multiple uses, transport between locations, recycling, and maintenance. Odell proceeded to consider how these aspects of curation are measured and how useful those measurements are to interpretation of curation behaviors.

Odell’s (1996) assessment suggests that production in advance of use, design for multiple purposes, and transport are all facets of curation behavior that are strongly linked to mobility/settlement behaviors. Recycling and tool maintenance, on the other hand, can reflect either curation behavior (by prolonging tool use-lives) *or* scarcity-induced economizing behavior (under conditions of raw material shortages). He concludes, therefore, that recycling and maintenance are not particularly useful in assessments of curation from archaeological assemblages. While Odell’s argument is sensible, it is difficult to separate these ideas, and to

distinguish the technological effects of economizing behavior from the technological effects of settlement/mobility-induced curation behavior. Raw material scarcity can be a product of mobility/settlement practices as well as a product of natural raw material occurrences and distribution. In other words, even in areas with accessible, good-quality stone raw materials, raw material scarcity may occur as mobile populations are forced to move away from these preferred sources in order to take advantage of other spatially or temporally patchy resources (e.g., subsistence resources). In this case, the structure of the local environment affects access to food, which impacts mobility patterns and consequently affects access to raw materials, creating the potential for lithic shortages and encouraging a curation strategy (i.e. producing tools during periods of down-time near the raw material source, transporting tools to the location of use, and rejuvenating those tools through periods of use).

While Odell had presented a reasoned critique of previous approaches, he still neglected to provide a new, usable definition of a concept that had become progressively more confounded. Shott (1996) attempted his own clarification and redefinition of the concept. He recognized that curation had become many things to many archaeologists:

It was tool transport between sites in mobile systems. But transport is caused by anticipation of continued use, which is a form of efficiency. Curation could involve caching and recycling and had the effect of prolonging use life. On one page Binford (1973: 242) described a corollary of curation, identified its causes, and assayed its consequences (Shott 1996: 262).

Neither Binford, nor anyone else since, had provided an explicit definition of curation.

Rather than abandon the concept, as some analysts had suggested, Shott (1996) was determined to provide a viable definition of curation. In constructing his own explanation, Shott first reviewed prior definitions in an attempt to demonstrate what curation is *not*. He argues that it is not multifunctionality, maintenance, hafting, repair, or complexity. Each of these, Shott

argues, “are distinct properties or practices whose own meaning (possibly excepting complexity) is clear; they may covary with curation but cannot be equated with it” (Shott 1996: 264).

Curation also is not anticipation of use. He reasons that all tools are designed for an anticipated use, even those we might call “expediently manufactured.” While the length of time between manufacture and that anticipated use may vary, the fact remains that the tool is being produced for use in either an immediate or future task. Curation is not transport. While transport may be a corollary of curation, it is not curation *per se*. Shott (1996) argues that tools can be curated without ever being transported. Similarly, use-life is not curation. It may covary with curation or be a corollary of it, but it is not curation in itself. Shott (1996) equates this distinction to the one that exists between body weight and height. While the two certainly are related and often covary, they are independent measures. Recycling is not curation, although curation may increase with recycling. Finally, efficiency is not curation. Shott argues that curation may be a form of efficiency, but “efficiency” has a wider range of meanings, including “how well and how much a tool is used, and how well a tool works in minimizing effort and returning useful products or results” (1996: 265). Shott says that efficiency measures a relationship between things, which is also what curation does – see below – and so curation can be considered a form of efficiency.

Shott (1996) then presents his notion of what curation actually *is*. He argues that

curation is a relationship between things. Because of their size, design, and working properties, all tools have a finite amount of value or utility. Use reduces this utility through wear, resharpening, chemical alteration, and the like. All tools are used to some degree up to the maximum utility they possess. Curation is *the degree of use or utility extracted, expressed as a relationship between how much utility a tool starts with – its maximum utility – and how much of that utility is realized before discard* (Shott 1996: 267, original emphasis).

This definition subsumes most prior definitions or aspects of curation, such as transport and recycling, both of which can be viewed as contributing to an increase in curation.

Shott (1996: 267) recognizes the potential for certain objections to his definition, and provides an example to illustrate his views. He considers a large, hafted tool that is used over a prolonged period of time and eventually depleted, and a small, hand-held tool that is depleted over the course of a single episode of use. Most archaeologists would consider only the former tool to be “curated” under traditional understandings of the concept. Following Shott’s (1996) definition, though, the two tools are actually equally curated. The difference between them lies in their design and their intended use within the culture’s technological organization scheme. For analysts who study the tools, they also differ in their interpretive value. The former represents an example of planned use over time, while the latter provides insight into activities at a specific moment in time. Following Shott’s (1996) definition, we must cease to view curation as a nominal variable, one that regards tools as either curated or expedient. Instead, curation is a continuous property of tools that has no opposite. So-called “expedient” tools are simply less curated than others.

Influences on curation are multifaceted and can include elements such as mobility frequency and raw material availability (Shott 1996: 268). These factors interact in complex ways to produce a curation strategy, which influences the formation of assemblages. For example, “increasing curation probably correlates often – although not necessarily always – with increased use life. Increasing curation may also correlate with an increased incidence of multifunctional tool classes because, trivially, one way to increase a specimen’s extracted utility is to employ it in a wider range of tasks” (Shott 1996: 269).

Shott (1996: 271) recognizes that the difficulty with his approach lies in operationalizing the definition of “utility.” While it is simple enough to discuss utility in a theoretical sense, it is more difficult to observe an archaeological specimen and determine whether or not it was used to

depletion, or if it entered the archaeological record before reaching that point. There are attributes we can study that can provide some insights into this question. I will return to this point in Chapter 5.

Shott summarizes his perspective by likening curation, in the archaeological sense, to tending to and caring for objects for the future. He indicates that “Both practices involve retaining objects because they will continue to be useful in the future...Both thereby engage the concept of utility and the practice of retention against the prospect of future use” (Shott 1996: 274).

Shott’s definition implies a focus on toolmaker choice. The decision about whether to maintain items for future use suggests forethought, as toolmakers and tool users either anticipated that items would continue to be useful/desirable *or*, alternatively, that there would be no future need for them. This decision is governed by factors such as: the requirements of tool function (e.g., intensity of tool use, length of time for which tools will be used, nature of use episodes), access to raw materials (based on local geology and/or the nature of mobility strategies; i.e., will toolmakers have access to preferred material sources?), requirements or limitations of the mobility strategy (e.g., the need for portability weighed against the need for access to raw materials), and risk (e.g., the risk of failing to meet subsistence requirements in harsh and unpredictable environments as a result of being unprepared for various circumstances).

These technological decisions are reflected in the differing emphasis on certain elements or variables in the production of tools and technologies. The way in which “these variables are emphasized or deemphasized in a prehistoric context depends on the conditions and strategies appropriate to a context” (Nelson 1991: 66). Variables include: reliability, maintainability, flexibility, versatility, and portability (Nelson 1991: 66). Toolmakers choose among these

alternatives, and select which to emphasize, in response to various conditions that are influenced by the nature of the environment, settlement-subsistence strategies, raw material availability, and functional requirements. The choice is made by weighing the advantages and disadvantages of each and is reflected in the material appearance of tools and the toolkit (Nelson 1991: 66). In other words, interpreting the behavioral basis for the nature of the lithic assemblage entails considering the presence or absence of these variables within the broader context of the physical environment and the requirements of the socioeconomic system. These technological variables, each of which is discussed below, are manifested in a variety of measurable attributes, which will be considered in Chapter 5.

Reliability

Reliable designs are those that function when they are needed (Bleed 1986: 739; Nelson 1991: 66). They tend to be produced with dependable parallel or substitute parts to mitigate the potential failure of components (Nelson 1991: 66). Tools in reliable systems are strengthened and overdesigned, meaning that components are sturdy enough to withstand stress. Their parts are carefully fitted and well-crafted and tend to be stronger than minimally required in order to prevent breakage at critical times. Reliable systems are characterized by redundant components that can be utilized to perform or complete the same task and replacement parts that serve as back-ups in case of failure (Bleed 1986: 740; Nelson 1991: 69). Standardization of the form and size of hafting elements serves to facilitate this redundancy in reliable technologies.

The design of reliable tools involves substantial investment of time and energy in the procurement of raw materials and in the manufacture and maintenance of those tools. The costs incurred as part of these design choices are balanced by the benefits of efficiency in tool use

(Nelson 1991: 67). Periods of maintenance and repair occur during predictable episodes of “down time,” which is an important strategy in “risky” environments, where efficiency in search and pursuit is extremely important. By removing repair and maintenance from the use context, time and energy are not diverted away from the important activities in which tools are being used (Bleed 1986: 740; Hayden et al. 1996: 12; Nelson 1991: 67).

Reliable technological systems tend to be selected by groups who engage in specialized, repetitive activities (Bleed 1986). Nelson suggests that reliable designs “are best suited for achieving returns when there is a premium on resource capture and processing time. In hunting, this may occur with either unpredictable or short time frames, where location and game type are predictable” (Nelson 1991: 67).

Maintainability

Maintainable tools are made to function under various circumstances. Unlike reliable implements, maintainable tools are repaired within use context and are generally simpler than their reliable counterparts (Bleed 1986: 740; Nelson 1991: 70-71). Nelson identifies two design sub-strategies within maintainable systems that fulfill the requirement for multi-use tools: “those which are changed in form to achieve multifunctional demands (flexible), and those which are maintained in a generalized form to meet a variety of needs (versatile)” (1991: 70).

Flexibility

Tools that are flexible can be changed in form in order to meet a variety of needs (Nelson 1991: 70). Flexible designs can either be modular, with interchangeable components (e.g., a multi-head screwdriver), or serial, undergoing successive episodes of reworking and continued

use (e.g., serial reduction through grinding metal tool edges). It should be noted that, in serial systems, if one component fails, the entire system fails (Bleed 1986: 740; Hayden et al. 1996: 13). Modular flexibility is a response to potential anticipated failures, mitigating those failures through the use of replaceable or repairable elements, such as replaceable foreshafts that hold different tips, or tools with identical haft morphologies but different tips, which facilitates replacement. Replacement/repair can occur during periods of use, using specialized repair kits (Bleed 1986: 70).

Versatility

Rather than being flexible, a maintainable technology may instead be versatile. Tools that are versatile exhibit a generalized design that is retained through maintenance episodes and can be used to accomplish a variety of tasks. Versatility can be recognized by considering the “number of task applications to which a tool class could be applied” (Nelson 1991: 71), which can be measured by considering the number of functional edges per tool (Shott 1986), or what Knudson (1973) called the number of “employable units” (EU). Generalized edge forms can also be produced to increase versatility (e.g., the machete used by Highland Maya).

Regardless of the particular form that maintainability takes, it entails costs in both manufacture and use. Flexibility incurs costs because taking time to reshape and replace components diverts time from tool use, and using versatile, generalized designs can consume more time than using forms that are designed specifically to carry out a particular task (Nelson 1991: 71). These costs are balanced by the benefits of “having a potentially wide range of tool-use options” (Nelson 1991: 71) available, which is of particular concern under conditions of unpredictability in the timing and/or location of use. Maintainable designs, which tend to be light

and portable, are considered characteristic of groups that are more concerned with transportation constraints and who face continuous technological needs under unpredictable conditions (Bleed 1986: 740; Hayden et al. 1996: 13).

Some researchers have asked whether maintainability and reliability are mutually exclusive (see Bleed 1986), or whether they should be viewed as “design concepts” that can be combined in various ways to answer organizational/problem-solving demands (Myers 1989: 87; Torrence 1989b: 63). Torrence (1989b) and Myers (1989) both view reliability and maintainability as responses to differences in the nature of risk, specifically in the severity and timing of risk. The severity of risk refers to “the consequences of failing to complete a task successfully” (Torrence 1989b: 63), and determines the degree to which reliability is emphasized. The timing of risk, on the other hand, refers to the factors that determine when tools need to be usable and governs the degree of emphasis placed on maintainability. Tools, therefore, can exhibit both reliability and maintainability. The degree to which one option is emphasized over another depends on how available the technological system needs to be (Bleed 1986: 739).

Portability

For mobile hunter-gatherer populations, a final technological concern revolves around making raw materials available when locations of use do not coincide with locations of procurement or manufacture. If tools are not made where they are used, portability becomes an important concern as toolmakers work to minimize limitations on population movements while maximizing available materials for the effective completion of tasks.

Some researchers have suggested that producing a portable toolkit should require minimizing the weight of implements or blanks (Ebert 1979: 68), but thinner tools are more prone to breakage during transport (Ellis and Spence 1997: 122). If this is the case, then the costs incurred through transporting slightly bulkier, more robust tools might outweigh the benefits of transporting lighter implements. The issue of portability must, therefore, be solved with consideration given to both mobility constraints and anticipated future needs.

SUMMARY:

BEHAVIORAL ECOLOGY AND THE ORGANIZATION OF TECHNOLOGY

Studies of the organization of technology consider the dynamic relationships between technology and the broader cultural system. Technology is viewed as a means of solving problems posed by the natural and social environments. In other words, “technology” does not simply refer to a set of tools; rather it is a form of goal-directed behavior, with the producers of the technology actively making *decisions* among alternative technological strategies in order to meet their biological and social needs most *optimally*. These decisions are made at various stages in the production, use, maintenance and discard cycle and can include decisions such as: which raw materials to exploit, how to exploit them, and how best to transport those materials; how much emphasis to place on curation, whether to produce a tool that can be used for extended periods of time, or whether a briefly used and immediately discarded implement will suffice; whether significant effort should be invested in reworking stone tools, or whether the production of a new tool is a more optimal alternative; and whether to discard a tool only when its maximum utility has been realized, or to discard the tool well before it could potentially fail.

Each of these technological concerns/alternatives carries costs and benefits that must be weighed against each other to produce a most optimal technological solution. That solution is, fundamentally, to have “a useable tool in the right place at the right time” (Nelson 1991: 76). These decisions are all made within the context of considering other biological and cultural goals so that technological behaviors contribute to the achievement of those goals rather than overshadowing them. For example, decisions about raw material choice and procurement scheduling must be made with consideration given to settlement-subsistence rounds so that tools are available for subsistence procurement and processing and so that toolmakers and users are not otherwise engaged at a critical time in the subsistence cycle (e.g., when a particular, temporally or spatially limited resource is available).

It is in the emphasis on *decision-making*, weighing of technological *alternatives*, and *optimization* of technological strategies that we can see overlap between the Organization of Technology and Behavioral Ecology approaches to understanding hunter-gatherer variability. Technology can be viewed as a mediator between people and their environments, acting as a buffer but also facilitating the extraction of resources from the environment. Behavioral Ecology teaches us that hunter-gatherers will respond differentially to different environmental structures (e.g., different climatic regimes, different resource distributions, differences in population density, etc.), and if technology is one means by which humans can overcome adaptive problems posed by the environment, then we should expect to see a correlation between variability in cultural responses (subsistence pursuits, settlement strategies, scheduling and organization, etc.) and variability in technological responses (i.e., the decisions that are made regarding optimal technological strategies to facilitate particular settlement-subsistence strategies).

This link between Behavioral Ecology and the Organization of Technology was the subject of Surovell's (2012) monograph in which he aimed to create formal models of lithic technology for hunter-gatherer populations. He noted that "The study of technological organization is...well suited to the use of formal models from behavioral ecology because decisions must be made at virtually every stage of stone tool production and use, and those decisions can be modeled as optimization problems" (Surovell 2012: 9). Surovell emphasized the influence that raw material variability and availability have on technological variability, and developed formal models that allow evaluation of hunter-gatherer mobility and occupation span, which could then be related to local environmental conditions. While elegant, his models are not entirely applicable to the Dust Cave context, or to this particular study. He relies on studies of debitage, which did not form a part of this particular analysis. In addition, he makes the assumption that tools transported to a site would have been produced of non-local materials. At Dust Cave, however, nearly all the lithic raw materials represented are ones that are available in the environs of the site. Applying Surovell's models to the case of Dust Cave would make it appear as though this forager population was quite sedentary. Regardless, Surovell's (2012) approach represents one of the most well-reasoned arguments for a connection between Behavioral Ecology and Technological Organization.

This dissertation takes a Technological Organization approach to the study of the lithic materials from Dust Cave, while attempting to integrate the patterns noted in the lithic assemblage with those Behavioral Ecology-based interpretations of patterns in the subsistence data. Research on the subsistence remains from Dust Cave (see Carmody 2009; Hollenbach 2005, 2009; Walker 1998) has demonstrated changes in the use of habitats by the human populations that inhabited this site. These shifts in habitat use have been interpreted as adaptive

responses by hunter-gatherer populations who were seeking to maximize their rate of energy capture within the changing local environmental setting. If we accept the goal of maximization in subsistence pursuits, and we accept that the technologies were designed to facilitate achievement of those goals, then technological design should be undertaken with a similar goal of maximization or optimization in mind. Specifically, hunter-gatherers should choose technological designs that enable other non-technological goals to be met most optimally, and thus technologies should contribute to the reproductive success of individuals.

While the range of resources available in the region and the range of activities performed appear to have remained fairly consistent throughout the Late Pleistocene and Holocene occupation of Dust Cave, it is apparent from the archaeological and paleoclimatic data that very definite shifts occurred in the density of certain resources, the structure of certain resources, and the particular ways in which human populations responded to those shifts and exploited the changing resource distributions. While the Late Paleoindian and Early Archaic inhabitants of the site appear to have used the location as a centralized residential base for the seasonal exploitation of a wide variety of resources, the Middle Archaic occupants appear to have used the site primarily as a specialized nut procurement and processing station.

This shift at Dust Cave from a more residentially organized settlement strategy to a logistical strategy, as argued by Carmody (2009), should be visible in the technological assemblage. As discussed above, several researchers have assessed the circumstances under which various technological responses should be expected (e.g., Binford 1973, 1977, 1979, 1980; Bleed 1986; Hayden et al. 1996; Kelly 1988; Kuhn; 1989; Shott 1986; Torrence 1989). These responses are governed by the constraints that arise through potential conflicts in the scheduling, location, and organization of technological, subsistence, and other cultural activities within both

the natural and social environments. When these activities, for which functional tools and toolkits may be required, are carried out at locations removed from the source of raw materials, then raw material and design constraints may become significant factors influencing technological design and production.

Examination of the subsistence and feature data by other researchers (Carmody 2009; Hollenbach 2005, 2009; Homsey 2004; Walker 1998) has suggested that residential mobility may have been relatively high in the Late Paleoindian and Early Archaic periods. Hollenbach (2005, 2009) has argued that Dust Cave may have served as a residential site during the early occupations, and one from which logistical forays for particular resources may have been organized. The faunal and botanical data indicate the use of a wide variety of resources, many of which likely were targeted during the Fall. With this mix of mobility strategies being employed, the lithic assemblage should reflect a correspondingly varied set of technological responses designed to meet the demands of frequent movement, as well as the demands of intensive, targeted resource procurement.

With these mobility and subsistence patterns in mind, it is possible to outline a set of technological expectations. If the site was used as a residential base – a locale where people lived for an extended period of time, carrying out domestic activities, and organizing subsistence pursuits – then the technological assemblage should be relatively diverse, reflecting this range of activities. Residential mobility might also be signaled in the technological assemblage by the presence of “exotic” or non-local raw materials that were extracted from locales removed from the site under consideration. The problem with this interpretation at Dust Cave, though, is that many of the apparently “non-local” cherts are available in the bed load of the Tennessee River and likely represent locally acquired materials.

In designing technological systems within a context of high residential mobility during the Late Paleoindian and Early Archaic periods, toolmakers may have emphasized reliability as a design consideration (Bleed 1986: 740; Hayden et al. 1996: 12; Nelson 1991: 67). An emphasis on reliability is seen in “risky” environments, or ones in which the chances and consequences of not meeting particular goals is especially high. This design choice is reflected in the creation of carefully crafted, well-fitted pieces, including the use of standardized hafts, which allow redundancy of lithic components. Effort is put into the production and maintenance of items, as well as into careful raw material selection. If residential mobility was high during the Late Paleoindian and Early Archaic periods, then we might expect to see an emphasis on well-designed tools, haft standardization, the use of high-quality lithic raw materials, and the inclusion of non-local materials that were acquired elsewhere in the settlement round.

The proximity of Dust Cave to a high quality, easily accessible raw material source likely produced certain technological patterns during the site’s tenure as a residential base. First, toolmakers on the site may have replenished their toolkits during periods of down-time. Examination of the discard patterns should reveal evidence for retooling, including the presence of exhausted implements that were discarded at the site, as well as flawed, abandoned pieces and tools that were broken during the process of manufacture. Exhaustion may be identified through changes in working edge morphology and reduced tool dimensions. Unused pieces, however, are those that exhibit sharp edge margins, no evidence for reworking, and no macro- or microscopic evidence for functional wear. These unused pieces may exhibit flaws or manufacturing breaks.

Second, given the close proximity of the Blue Grey Fort Payne source, stone raw material economy likely was a minor concern. While toolmakers geared up toolkits with more formal, standardized, easily maintained implements for use elsewhere in the subsistence round, tool users

may have relied on a simple flake technology for carrying out many tasks on-site. The use of simple flake tools, with generalized, sharp margins, would have enabled a wide variety of tasks to be carried out, without diverting time and energy away from the production and/or maintenance of more formal implements that would have served tool users during residential moves or on logistical forays away from the base.

While it has been argued that Dust Cave served as a residential site during the Late Paleoindian and Early Archaic, it seems that some subsistence resources were targeted logistically, with task groups being mobilized to provision the Dust Cave population from locales removed from the site. Logistical procurement has been associated with an emphasis on maintainability in technological systems (Bleed 1986: 740; Nelson 1991: 70-71). Maintainability is selected as a technological strategy by groups that experience continuous technological needs under unpredictable conditions, and when the timing of risk is uncertain. This design consideration ensures that tools are usable when they are required, even when precise tool requirements (tool types and timing of use) are uncertain. Maintainability may be achieved through emphasizing flexibility (i.e., changing the design of the tool to meet a variety of needs, or through the use of modular or serial components) or versatility (i.e., producing tools with multiple edge units or generalized edge forms in order to allow the accomplishment of a variety of tasks). Producing a maintainable technology entails costs in manufacture and maintenance, but these costs are balanced by benefits in use efficiency, specifically through the creation of a wide range of available tool use options.

These technological expectations persist throughout the Late Paleoindian and much of the Early Archaic. By the end of the Early Archaic and during the Middle Archaic, however, a transition is noted toward more intensive use of plants, which has been interpreted as

representing the beginnings of a shift toward the use of Dust Cave as a specialized logistical procurement station, rather than a residential base (Carmody 2009). By the Middle Archaic, a great emphasis is noted on nut procurement and processing, although terrestrial mammals such as deer and squirrel were also targeted. Dust Cave appears to have become a logistical station that provisioned a residential base located elsewhere.

Because site use seems to have become more narrowly focused in the Middle Archaic, a reduction in technological diversity is expected. A narrower range of tools would reflect the reduction in domestic tasks on site, and an increased focus on nut procurement and processing. Chipped stone tools likely diminished in importance at Dust Cave, as nut procurement and processing would have required a different set of tools (e.g., ground stone tools, bags, baskets, roasting platforms). Chipped stone tools would, nonetheless, have been required for use at the residential base, and during other logistical forays. Given that Dust Cave is located in close proximity to a high-quality, easily accessible raw material source, the population that used the cave may have taken advantage of this raw material source opportunistically, during the execution of other activities. As Dust Cave began to assume the role of specialized extraction locale within an increasingly logistical settlement system, we might expect to see an increasing emphasis on versatility (i.e., more generalized tools for carrying out a variety of potentially unanticipated tasks). One form that this increased versatility may have taken is in an emphasis on simple flake technologies for use on-site, rather than emphasizing the production of more formal implements. While at Dust Cave, where raw material economy would have been of little concern, tool users could easily have accomplished certain tasks not related to nut processing by using expediently produced flake tools.

Examination of various stone tool attributes can enlighten us about the particular concerns being faced by toolmakers and tool users. Identification of these attributes, which will be discussed in Chapter 5, allows us to approach the context in which these decisions were being made. For example, it becomes possible to interpret whether populations were highly mobile or more sedentary or whether hunter-gatherers were faced with predictable or unpredictable subsistence availability and activity scheduling. We may also consider whether the population faced constant subsistence pressures or whether they were able to procure or store certain resources in large enough quantities to afford them some valuable “down time.” Finally, it is possible to assess whether technological production was constant or *ad hoc*, or whether toolmakers engaged in periods of “gearing-up” in anticipation of predictable future needs.

The Organization of Technology approach can provide lithic analysts a valuable means of interpreting non-technological behaviors, environmental patterns, and adaptive responses from sites where only lithic artifacts have been recovered. It is a way to interpret environmental change, settlement strategies, and subsistence/economic activities when no direct evidence of these patterns or behaviors is recovered. The current analysis of the lithic assemblage from Dust Cave, however, is bolstered by copious data on subsistence practices, the structure of the local environment, climate change, activity patterning within the site, and site formation processes. This rich dataset presents the opportunity to evaluate the ways in which technological design contributed to and facilitated adaptive cultural responses to the documented environmental and corresponding socioeconomic changes from the Late Pleistocene through the mid Holocene.

CHAPTER 4: MATERIALS – DEFINING THE DUST CAVE TYPOLOGY

Excavations at Dust Cave have produced an array of technological traces, including chipped and ground stone tools, bone and antler tools, cooking technology (e.g., fire-cracked rock, prepared clay surfaces), and evidence for textiles (Sherwood et al. 2004; Sherwood and Chapman 2005). While I will reference many of these other items of technology in my discussions of the use of the cave, the focus of my analysis is primarily on the chipped stone tool assemblage.

This chapter presents the typological scheme for the Dust Cave assemblage and presents a description of the various tool classes that have been identified. The typology developed here is based on the generalized classification schemes devised by Andrefsky (2005) and Odell (2003), and draws elements from the typology created by Driskell (2011: 193-294; Driskell et al. 2011: 168-254) for the Townsend Archaeological Project. The classification scheme described below borrows from these various typological systems and adapts them to the particular assemblage from Dust Cave. Summary measures for the various tool classes are presented throughout the chapter and are derived from the primary measurement data in Appendix A at the end of this volume.

The collection of chipped stone tools studied here comprises a total of 2120 artifacts. This sample encompasses all of the known tools from the site, including specimens identified during the excavations, and those identified during lab work. While initial cataloging was carried out in the field, I reexamined all of the tools listed in the master catalog and reclassified when appropriate. In addition, I recorded several previously unrecorded specimens that had been excavated during later seasons of the project. It should be noted that some tools may remain in

the bags of chipping debris, which I did not examine over the course of this project. Given that much of the excavation was conducted as part of field schools, inexperience in identifying artifacts may have led to some tools being misclassified. Careful examination of the debitage is still warranted.

DUST CAVE TYPOLOGY

In assessing large collections of lithic materials from archaeological sites it is useful, for analytical purposes, to partition the collection into classes or types that allow the researcher to ask questions about the roles of various tool categories. The typology for the materials discussed in this volume is displayed graphically in Figure 4.1. Construction of this typology is discussed, below.

In developing any lithic typological scheme, we may first draw a distinction between items identified as “tools” and those non-tool items that are also recovered. For the purposes of this project, the category of “tools” includes all chipped stone artifacts that exhibit modification by toolmakers or tool users. This modification can be applied intentionally in order to produce, refine, or rejuvenate a working edge or to alter the desired morphology, or it can be produced incidentally as edge damage incurred during the use of a tool (Andrefsky 2005: 76; see also Microwear Methodology in Chapter 6). Pieces that are created through human agency but that have not been modified subsequent to their removal from the parent piece of raw material are categorized as “non-tool” artifacts.

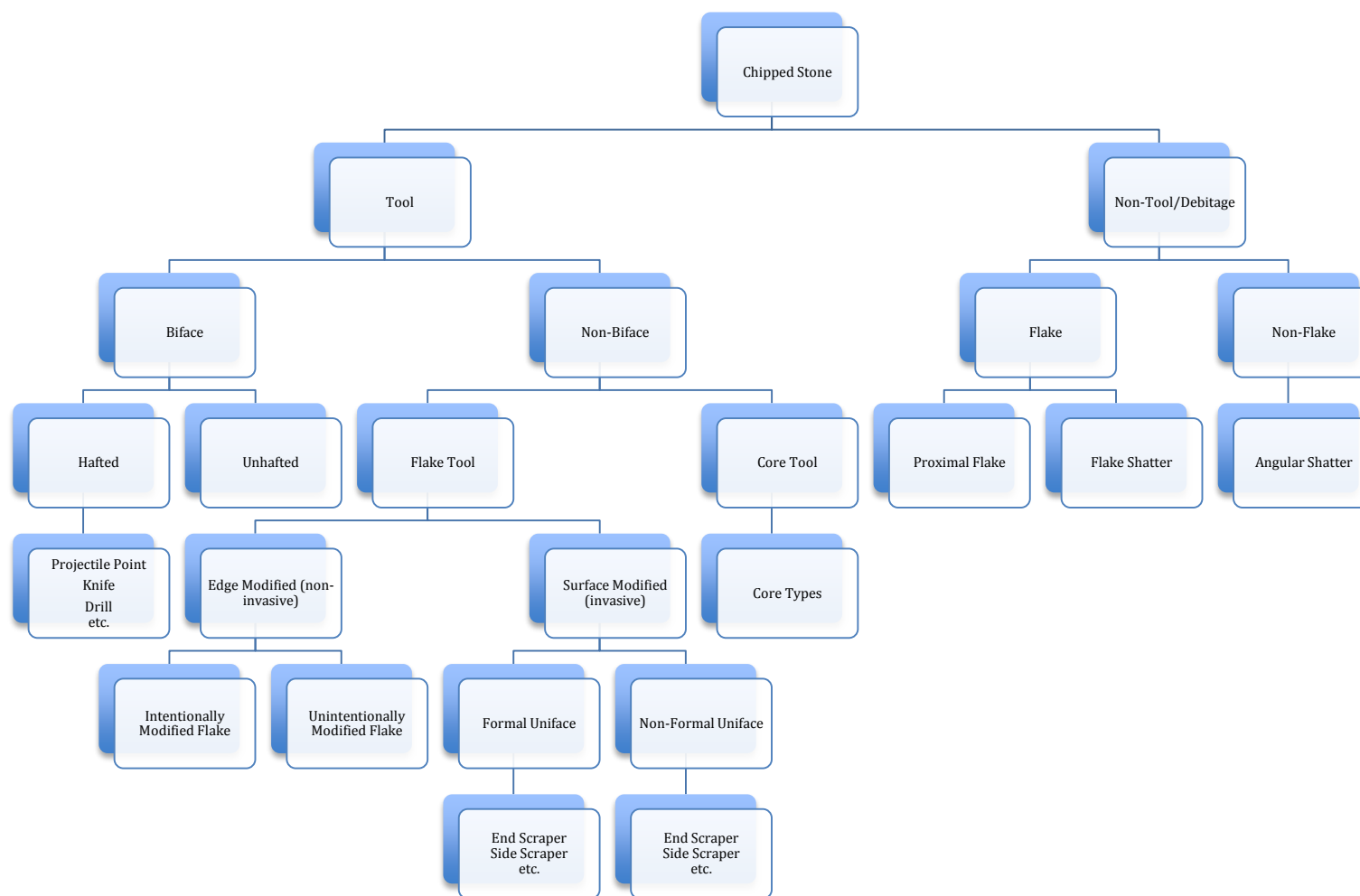


Figure 4.1: Dust Cave Chipped Stone Typology. Adapted from Andrefsky (2005), Driskell (2011), and Odell (2003).

The “tool” and “non-tool” categories can be further refined. “Non-tool” artifacts, commonly called debitage or flaking debris, consist of “the discarded and unused detached pieces of lithic material produced from the reduction of an objective piece” (Andrefsky 2005: 82). Some of these pieces retain identifiable flake characteristics, such as a recognizable dorsal and ventral surface, a striking platform, and a bulb of percussion, while others do not. Inspection of the piece of debris for these characteristics allows a division to be drawn between flake and non-flake debitage. While I will discuss patterns in the presence of debitage at this site, its analysis is not a major focus in this dissertation.

Tools may be subdivided into biface and non-biface categories. Bifaces are those tools that have been flaked on two faces that meet to form a continuous edge, which circumscribes the entire artifact (Andrefsky 2005: 77). Non-biface tools are items that have been flaked on fewer than or more than two surfaces, or on which no continuous edge is identifiable.

Bifaces are categorized into hafted and unhafted types. Hafted bifaces exhibit modifications (e.g., notching, stemming, grinding, thinning) that facilitate attachment of the tool to a handle or shaft/foreshaft. This category includes items such as projectile points, knives, and drills. Unhafted bifaces, on the other hand, exhibit no such modifications and include types designated as preforms/stage bifaces, broken projectile or knife tips, and hand-held knives or choppers.

The category of “non-biface” tools includes both flake tools and cores. Flake tools are non-bifacial “objective pieces that have been produced from a flake blank that has been modified to some extent, and may no longer possess the original flake characteristics” (Andrefsky 2005: 78). While some of the original flake characteristics such as a bulb of percussion, distinguishable proximal and distal ends, and an intact striking platform may no longer be visible on these

implements, the presence of an identifiable dorsal and ventral surface is essential to their identification. Non-biface implements that do not exhibit a distinctive dorsal and ventral surface are classified as cores (sometimes referred to as “core tools;” see my distinction and discussion, below).

Flake tools can be further divided based on the extent or invasiveness of the secondary flaking applied to them. Following Odell (2003: 108), a distinction is drawn between those flake tools that exhibit surface modification and those with non-invasive/edge modification. Edge retouched specimens are those whose flake scars extend no more than 5-8 mm on to the surface of the tool, while surface-retouched specimens are those with flake scars that “reach toward or attain the center of the surface or beyond” (Odell 2003: 108). In the current typological scheme simple, intentionally and unintentionally modified flakes (sometimes called retouched and utilized flakes, respectively) are included in the category of “edge retouched flakes.” Invasively retouched flake tools, on the other hand, include the various categories of formal and informal unifacial implements.

Below are described the various tool types that fall into each of the abovementioned categories. Individual specimens of interest are indicated by reference to the last five digits of their accession numbers (Acc. No.) listed in the data sheets presented in Appendix A. While the merits of typological schemes in general, and techno-morphological or functional type names in particular, have been debated thoroughly in archaeology (e.g., Adams and Adams 2007; Dunnell 1986; Hill and Evans 1972; Whittaker et al. 1998), these generally recognized type names are used here simply for their heuristic value. These are names that are commonly recognized within archaeology and lithic analysis and therefore provide a useful means of labeling and communicating about the various classes. Beyond simply equating form with function, though,

the descriptions provided in this chapter consider the morphological and technological attributes that characterize each type. In addition to these facets of the tool description, tool function is assessed in Chapter 8, through the application of microscopic use wear analysis. Microwear analysis provides both a means of assessing the functions of individual tools and the patterning within the type categories defined here, serving to elucidate whether artifacts within these categories were used in similar manners.

TOOL CATEGORY DESCRIPTIONS

Biface Tools

Bifaces, defined above, are the most common class of tools in the Dust Cave assemblage (n=761). This general type can be divided into hafted and non-hafted variants based on the presence or absence of modifications to the proximal end of the tool that facilitate attachment of the implement to a shaft or foreshaft. These hafting modifications are identified by the presence of notches, shoulders, stems, or some other identifiable break in the outline morphology of the tool. Following Andrefsky (2005: 77), “The hafted biface category includes all those items traditionally recognized as arrow points, spear points, hafted knives, and hafted drills. The [non-hafted] biface category includes all those bifaces that simply do not have haft elements, and are known as performs, point tips, and bifacial knives, etc.” Below are presented the various categories of biface tools, both hafted and unhafted, that have been identified in the Dust Cave assemblage.

Non-Hafted Stage Bifaces (Figure 4.2)

The term “Stage Biface” is used here to refer to a variety of non-hafted biface tools that can be differentiated on the basis of the degree of flaking applied to the artifact (Figure 4.1). They represent pieces from various points along the bifacial reduction sequence, from early-stage, roughly worked pieces, to later-stage, finely finished implements. While some of these stage bifaces may represent items that were broken or abandoned during the production process, others likely were used as-is, regardless of whether or not they proceeded through the “perform” stage (i.e., Trimmed Biface I & II categories) to become finished, hafted implements. These cruder items may have been large knives or choppers.

There have been debates among lithic technologists about the validity of viewing lithic reduction as a “staged” process. Morrow (1996), Sanders (1990), and Whittaker (1994) all argue for the notion of stages in the reduction sequence, while others (e.g., Amick 1985; Bleed 2002; Bradbury and Carr 1999; Ingbar et al. 1989; Johnson 1989; Shott 1996; Wilson and Andrefsky 2005) have argued that the production of bifaces should be viewed as a continuous rather than a staged or segmented process. While biface reduction sequence may very well have occurred as a continuous procedure, rather than being partitioned into distinct stages by the toolmaker, the argument can be made that the invocation of stages as an analytical device may still be useful and quite reasonable when one considers large collections of bifaces.

First, there are points in the lithic reduction process at which a flintknapper will change his goals or strategies. He may abandon the use of a hard hammer in favor of a soft billet, or he may change from a percussor to a pressure flaker in order to refine an edge margin. Second, regardless of whether production was a staged or continuous enterprise, toolmakers likely viewed the crude, thick, unrefined bifaces from earlier in the reduction sequence in a very

different light from those thin, refined, hafted tools that emerge at the end of the sequence. These two ends of the spectrum represent items that are morphologically, technologically, and functionally quite distinctive. Finally, we see cases in which a distinct break in the production sequence can be identified. Many archaeologists have suggested that mobile forager populations who used quarry sources at locations removed from their activity locales and camps often reduced raw materials to transportable cores at the quarry site (e.g., Metcalfe and Barlow 1992). These pieces, after initial production and removal from the raw material source, could be used as sources of flakes for tool production, as large cutting or chopping tools, or could have been further reduced into more finely worked hafted bifacial implements (Kelly 1988). The notion of stages in the reduction sequence therefore is entirely plausible. But beyond simply its plausibility, partitioning bifacial assemblages according to reduction stage becomes very useful for the purposes of study, as it provides a means of reducing a large amount of variation into more easily assessed segments.

We may define these divisions by considering several features that vary through the production and use lives of bifacial implements. While all stage bifaces exhibit the basic characteristics required for inclusion in the category of “biface” (see above), they vary according to their thickness (relative to width), the sinuosity of the edge, and the edge angle. In addition, Miller and Smallwood (2012) have proposed that reduction stages may be recognized by considering the Flaking Index, calculated as the number of flake scars per unit of edge length. As bifaces progress through the reduction sequence, from raw material to finished, hafted biface, they become thinner, their edges become less sinuous, their edge margins become more acute, and the number of secondary flake scars increases per unit of edge length. Using these criteria, I have partitioned the Dust Cave biface assemblage into four categories: Early Stage Biface, Mid

Stage Biface, Trimmed Biface I and Trimmed Biface II. Early and Mid Stage Bifaces may be considered either bifacial tools or cores, while the Trimmed Bifaces may represent non-hafted knives, or “preforms” for hafted bifaces.



Figure 4.2: Non-Hafted Bifaces. (From left to right: Early Stage Biface, Mid Stage Biface, Trimmed Biface I, Trimmed Biface II)

Early Stage Biface (ESB; n=18)

Early Stage Bifaces tend to be large (see Tables 4.1 and 4.2) and crude in appearance. They exhibit all the requisite characteristics for inclusion in the category of bifaces but are significantly less refined than later-stage members of the class. Many of the Early Stage specimens are very thick (see Table 4.2) and quite angular in appearance, with pronounced sinuosity of the edge margins produced through quite invasive flake removal. The mean width to

thickness ratio for this class is quite low (\bar{x} =2.41, SD = 0.58), indicating that these ESB specimens tend to be less than 2.5x as wide as they are thick (compare to ratios of later stage specimens, discussed below).

Flaking on these specimens is minimal, compared to examples from later stage categories. Several specimens retain cortical or weathered surfaces (18%), as the flaking had not yet extended onto the surface of the tool to remove it. The average flaking index for the Early Stage Bifaces is low, indicating few flakes per unit length (\bar{x} =0.041, SD=0.008; an average of 0.4 flakes per cm).

While later stage specimens tend to exhibit refined outline morphologies and a very distinctive shape (e.g., lanceolate, ovoid, parallel-sided, etc.), these earlier stage specimens are more “amorphous” in appearance. These artifacts may represent bifacial cores (a source for flakes) or very early stage preforms in the production of more refined bifacial implements. It is also possible that they could have been used as heavy chopping implements, except macroscopic examination did not reveal evidence for the sort of impact damage that we would expect from use in such an activity.

The Early Stage Bifaces are all produced from either Fort Payne or Blue-Grey Fort Payne chert. Proportions of complete/relatively complete and fragmentary specimens are quite close, being 55.6% and 44.4%, respectively. These tools were recovered in low numbers from Dust Cave, but excavations at the nearby sites of Lithic Shoals (1LU342) and ILU25 revealed large quantities of crude bifaces produced through initial reduction of river cobbles (Meeks 1997). These sites are located within 1000 meters of Dust Cave.

Table 4.1: Mean Length for Early Stage Bifaces. (Complete specimens. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	10	58.11	89.94	77.9820	9.85842
Valid N (listwise)	10				

Table 4.2: Mean Width and Thickness for Early Stage Bifaces. (All specimens. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	18	38.14	64.35	53.5400	7.94773
THICKNESS	18	16.32	32.34	23.1283	5.03341
Valid N (listwise)	18				

Mid Stage Biface (MSB; n=49)

Many of the pieces in the Mid Stage Biface class are fairly large, but the category as a whole appears more refined than the Early Stage Bifaces. Mean length, width and thickness measurements have decreased, compared to corresponding ESB measurements (see Tables 4.3 and 4.4). These artifacts had begun to assume a distinct morphology, often ovoid or rectangular in outline. Achieving this general form and executing some thinning appear to have been the primary concerns at this stage of production. A small proportion of specimens (18%) exhibit cortex, but it exists in much more restricted patches than seen among the ESB specimens.

The MSB specimens are thinner, on average, than their ESB counterparts. A mean width to thickness ratio of 2.80 (SD=0.70) indicates that the MSB specimens are nearly 3 times as wide as they are thick, which represents a decrease in relative thickness compared to the ESB average.

Table 4.3: Mean Length for Mid Stage Bifaces. (Complete specimens only. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	11	55.91	95.22	74.1127	11.75797
Valid N (listwise)	11				

Table 4.4: Mean Width and Thickness for Mid Stage Bifaces. (All specimens. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	48	20.81	66.67	41.9348	11.12613
THICKNESS	48	6.43	25.95	15.5238	4.21456
Valid N (listwise)	48				

In addition to these tools appearing thinner, they also exhibit a greater degree of refinement, as indicated by an increase in average flaking index ($\bar{x}=0.08$, $SD=0.01$) to 0.8 flake scars per cm. This stage in the production sequence therefore represents an attempt at refining both the overall shape and edge morphology of these tools.

Similar to the Early Stage Biface Category, nearly all specimens were produced from Fort Payne or Blue-Grey Fort Payne chert (95.9%; remaining 4.1% unidentified). The Mid Stage Bifaces include a higher proportion of fragmentary specimens (76.6%) versus complete and relatively complete specimens (23.4%).

Trimmed Biface I (TBI; n=388)

This category represents a continued refinement and thinning of the bifacial implements. These specimens are shorter and much thinner than either ESB or MSB specimens (Tables 4.5,

4.6), and most have taken on very regular outline morphologies (e.g., lanceolate, ovoid, parallel-sided, triangular, etc.). The mean width to thickness ratio has increased to 3.45 (SD=0.91) with a maximum value of 6.89. This means that Trimmed Biface I specimens are almost 3.5 times as wide as they are thick, on average, and that some specimens are nearly 7 times wider than they are thick.

Progressive thinning of these tools appears to have removed most of the remaining cortex, as I identified cortex on only 3% of the TBI specimens. Patches of cortex were restricted in both size and distribution, often being located on the tool bases. The more intensive flaking is also apparent in an increase in the number of flake scars per unit of edge length. The average flaking index increased to 0.16 (SD=0.03), indicating an average of 1.6 flake scars per cm. This increased intensity in edge flaking served to produce straighter, less sinuous edges among these specimens. These artifacts may have served as hand-held knives, or as hafted biface preforms undergoing their final stages of thinning and refinement prior to haft production.

Table 4.5: Mean Length for Trimmed Biface I. (Complete specimens only. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	77	38.87	113.84	64.8326	14.63764
Valid N (listwise)	77				

The Trimmed Biface I category includes 2.6% unidentified chert specimens, while the remaining 97.5% were produced from Fort Payne and Blue-Grey Fort Payne chert. Conditions of the implements are relatively unchanged compared to the Mid Stage Bifaces, with 20.3% being complete or relatively complete, and 79.7% being fragmentary.

Table 4.6: Mean Width and Thickness for Trimmed Biface I. (All specimens. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	379	9.20	69.69	32.2950	8.66498
THICKNESS	379	3.70	27.20	9.6932	2.86265
Valid N (listwise)	379				

Trimmed Biface II (TBII; n=306)

Much like the TBI category, these specimens are significantly more refined than the ESB or MSB examples. They exhibit very straight, non-sinuuous margins with particularly fine flaking. These artifacts likely served as either hand-held knives or as preforms for hafted bifaces, nearly complete with the exception of their hafting modifications. Tool length is reduced somewhat compared to the TBI specimens (Table 4.7).

Like their TBI counterparts, these specimens exhibit highly regular outline morphologies, and are quite thin compared to their widths (Table 4.8). The average width to thickness ratio for the TBII specimens is nearly identical to that of the TBI examples (\bar{x} =3.55; SD=1.04). The minimal and not significant difference in the mean ratios between these two categories suggests that continued thinning of the piece was *not* the primary concern at this stage. Overall dimensions had, apparently, already been achieved by this stage. Differences in width at this stage can easily be explained as a function of tool resharpening.

Comparing the average flaking indexes of the TBI and TBII specimens, however, demonstrates a notable increase in the latter category. The average flaking index of the TBII specimens increased to 0.28 (SD=0.07), indicating an increase to nearly 3 flake scars per cm of edge length. Two possible explanations exist for this pattern. First, the TBI specimens may

represent an earlier stage in the manufacture of bifacial knives or projectile tips than the TBII specimens, having not yet received their final edge modifications. Or, second, both the TBI and TBII categories might represent different stages in the *use* of these bifacial tools. TBI specimens might represent relatively unused tools that had only recently achieved a “finished” state as hand-held, bifacial knives, while the TBII examples, which exhibit finer flaking along the edge margins, might represent implements that had undergone at least one use and rejuvenation cycle. In other words, the finer flaking might not represent refinement of the edge margin, but instead may indicate retouch/resharpening following edge dulling. This latter possibility may account for the similarities in other aspects of the tool form and dimensions, while simultaneously explaining the differences in the average flaking index.

The TBII category includes a much higher proportion of fragmentary specimens than seen in any other category (90.1% fragmentary, 9.9% complete/relatively complete). The majority of these specimens were produced from Fort Payne or Blue-Grey Fort Payne chert (95.5%), with only a handful of examples of other materials noted (0.3% Quartzite, 0.7% Agate, 1.0% Chalcedony, and 2.6% unidentified).

Table 4.7: Mean Length for Trimmed Biface II. (Complete specimens only. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	30	30.99	95.96	61.6913	17.03314
Valid N (listwise)	30				

Table 4.8: Mean Width and Thickness for Trimmed Biface II. (All specimens. Primary measurement data available in Appendix A, Table A-1.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	302	4.28	46.65	23.9556	7.86925
THICKNESS	302	2.98	12.73	6.8382	1.69263
Valid N (listwise)	302				

Hafted and Probable Hafted Bifaces

Hafted Bifaces (HAB; n=297)

The tools classified as Hafted Bifaces conform to requirements for inclusion in the biface category, as described above. The majority of Hafted Bifaces were produced from locally available Blue-Grey Fort Payne chert. Unlike the previously discussed general biface categories, these specimens possess hafting elements, which are purposefully produced modifications that allow attachment of the tool to a handle, shaft or foreshaft for use a knife and/or projectile tip. For the purposes of this dissertation, my interest in these tools lies in their ability to provide insight into the chronological sequence of site occupation. Excavations of stratified sites in the Midsouth (e.g., Broyles 1971; Chapman 1975; Coe 1964) have revealed sequences of distinctive hafted biface forms, with particular blade and haft morphologies, that changed through time. These changing artifact styles can be used as diagnostic markers to record occupation span at sites, as well as to identify similar temporal-cultural occupations at non-stratified sites. The artifact sequence from Dust Cave includes a series of diagnostic forms that mark temporal, and perhaps cultural, changes in site occupation.

Because many microwear studies, including Meeks' (1994) functional analysis of hafted bifaces from Dust Cave, have demonstrated that these implements tended to be used either as

projectile tips (hunting activities; see Andrefsky 2005) or for butchering (e.g., Ahler 1971: 108; Andrefsky 2005: 204; Driskell 1986; Greiser 1977; Nance 1971), I do not focus on them as a great source of additional knowledge regarding prehistoric activities at the site. Instead, I refer to them primarily in order to distinguish chronological periods, to confirm the importance of both hunting and butchering activities in the subsistence cycle of the various occupations of Dust Cave, and as a source of information about the role Dust Cave played in the technology of these prehistoric inhabitants (e.g., how the decision to discard, as indicated by condition of the tools, figured into settlement/subsistence round).

To avoid the typological mire that can occur in projectile point categorization, I consider the hafted bifaces from Dust Cave using the framework of type clusters outlined by Justice (1987). Each cluster encompasses a variety of related types and their often region- or site-specific morphological correlates. Meeks (1994) has examined the major types identified at the site, and his analysis suggested that the morphological and technological characteristics of the Dust Cave specimens corresponded well with local and regional definitions of those types. The types identified, the clusters to which they belong, and the counts for each are presented in Table 4.9. Below, I provide brief descriptions of the types within each cluster identified. These cluster descriptions are arranged in chronological order, from oldest to most recent (see Figure 2.4).

Fluted Points (n=2): Fluted and Cumberland

The Fluted category represents Middle Paleoindian point types, which are quite uncommon at Dust Cave. Only two specimens were identified in the assemblage. One was simply labeled as “fluted” while the other was categorized as a reworked Cumberland (Lewis 1954). These forms are characterized by parallel-sided or lanceolate outline morphology and the

removal of elongated channel flakes (“flutes”) from the base. These channel flakes follow the long axis of the tool and, depending on the particular variety, may extend most of the length of the tool, or may be confined to the proximal portion of the implement.

Cumberland points (Lewis 1954), in particular, are long, narrow points characterized by recurvate margins that lend a fishtail shape to the outline morphology (Justice 1987: 25). The basal margin is concave and exhibits grinding that extends to the lateral margins of the haft element. The single Cumberland point recovered from Dust Cave was reworked into a long, narrow specimen that possesses an almost drill-like appearance.

Dalton Cluster (n=12): Quad, Beaver Lake, Dalton, Hardaway-Dalton, Greenbrier,
Russell Cave

These Late Paleoindian specimens resemble the earlier Cumberland forms, being fishtailed with recurvate edge margins, but they are unfluted and often appear broader-bladed.

The Quad variety, first described from the Quad site in northern Alabama (Soday 1954), is short, with recurvate margins, and prominent basal ears. Haft grinding is apparent on both the basal and lateral margins. These forms are occasionally fluted and were produced through fine-quality random or collateral flaking (Justice 1987: 36).

Beaver Lake points (Cambron and Hulse 1960b, 1969; DeJarnette et al. 1962) appear almost identical to Cumberland points, but lack fluting. They are slightly broader than Cumberland points, are thin in cross-section, and exhibit both lateral and basal haft grinding (Justice 1987: 35).

Table 4.9: Hafted Biface Counts per TCA, Cluster, and Type. (Data available in Appendix C, Table C-1.)

Temporal-Cultural Affiliation (TCA)	#	Cluster	#	Type	#
Middle Paleoindian	2	Cumberland	1	Cumberland	1
		Fluted	1	Fluted	1
Late Paleoindian	12	Dalton	12	Beaver Lake	4
				Dalton	2
				Greenbrier	1
				Hardaway-Dalton	1
				Quad	2
				Russell Cave	2
Early Archaic	101	Thebes	1	Plevna	1
		Large Side Notched	57	Big Sandy	47
				Early Side Notched	3
				Early Side Notched/Big Sandy	7
		Kirk Corner Notched	12	Kirk Corner Notched	11
				Palmer	1
		Le Croy	2	Kanawha	2
Middle Archaic	97	Kirk Stemmed	28	Kirk Serrated	23
				Kirk Stemmed	5
		Eva	4	Eva	4
		Morrow Mountain	12	Morrow Mountain	4
		White Springs	11	Crawford Creek	6
				Sykes	5
		Benton	58	Benton	54
				Buzzard Roost Creek	4
Late Archaic	7	Ledbetter	4	Elora	1
				Ledbetter	2
				Pickwick	1
Early Woodland	3	Dickson	3	Gary	1
				Little Bear Creek	2
Late Archaic/Woodland?	2	?	1	Frazier	1
		?	1	Jude	1

Dalton points (Chapman 1948; Goodyear 1974; Morse 1971) are lanceolate- or trianguloid-bladed implements that frequently show pronounced edge serration. Haft margins are parallel-sided to slightly incurvate. The haft exhibits a deeply concave, thinned, and heavily ground basal margin with ears that either flare outward or project downward. These tools appear to have undergone successive resharpening episodes, as indicated by the dramatically reduced blade width of many specimens, and the presence of alternate beveling and blade serration (Justice 1987: 40).

Greenbrier points (Lewis and Kneberg 1960; DeJarnette et al. 1962; Cambron and Hulse 1969) are lanceolate-bladed forms with expanding stems. These specimens appear to have undergone resharpening, as indicated by the presence of bifacial beveling of the edge margins. The haft is broadly side notched with an incurvate base and heavy lateral grinding (Justice 1987: 42).

Thebes Cluster (n=1): Plevna

A single specimen was identified as a Plevna point (DeJarnette et al. 1962; Cambron and Hulse 1969; Chapman 1975), which is a morphological correlate of St. Charles (Scully 1951). All types within the Thebes cluster are relatively large, with either broad triangular blades or narrower lanceolate blades, notching (side or corner), and often fairly imposing bases of various shapes.

Plevna/St. Charles points are lanceolate- to ovoid-bladed forms with deep, narrow corner notches and convex bases. The base is often produced with two or three flattened facets that create a trapezoidal haft, with the shorter of the two parallel margins as the basal margin (Justice 1987: 57).

Large Side Notched Cluster (n=57): Early Side Notched, Big Sandy, and ESN Big Sandy Big Sandy points (Kneberg 1956; Cambron and Hulse 1960a, 1969) possess narrow, elongated, trianguloid blades with side-notching. Resharpening of these forms produced beveling and serration of the edge margins.

The haft element was produced through the application of shallow side-notches, with notching techniques varying “from indentations produced bifacially following a single inward direction, to those exhibiting a Y-pattern resulting in two notching directions in the interior of the notch” (Justice 1987: 60). The latter technique produced two overlapping hertzian cone scars. Basal margins are straight to deeply concave or almost bifurcated, and exhibit pronounced thinning. Basal ears are squared to rounded, and hafts often exhibit full grinding.

Kirk Corner Notched (n= 12): Kirk Corner Notched, Palmer Corner Notched

Only 12 specimens identified as Kirk Corner Notched were located in the Dust Cave deposits. The relative absence of this horizon, which is otherwise common across much of Eastern North America (see, for example: Coe 1964; Daniel 1998; Ellis et al. 1991; McMillan 2003; Tuck 1974), is attributed to an apparent erosion event in the cave, as evidenced by an abrupt change in sediment characteristics. Sherwood et al. (2004: 547) note a “stratigraphic disconformity...between Zone R [Early Side-Notched] and the overlying Kirk Stemmed component.” This disconformity spans a period from approximately 10,800 to 10,000 cal BP, and is interpreted as having been the result of a major fluvial event (Sherwood et al. 2004: 548).

The few Kirk Corner-Notched projectile points (Broyles 1971; Coe 1964) that were recovered conform to the common type description of large, triangular-bladed forms with straight to slightly rounded bases. Blade margins are bifacially serrated and may exhibit

beveling. Very little blade variation is noted as a result of resharpening. These tools were produced through the removal of wide thinning scars that extended across the surface and produced a flattened cross-section. Basal grinding is absent on Kirk Corner Notched specimens (Justice 1987: 71).

Palmer points (Coe 1959, 1964) are smaller than Kirk Corner Notched specimens. The Palmer points are corner notched, with biconvex cross sections, pronounced blade serration, and barbed shoulders. Cross-sections are biconvex. These forms exhibit slightly concave to convex, thinned, and heavily ground bases. Palmer points are also known as “Kirk Corner Notched (small variety)” (Broyles 1971; Chapman 1977).

LeCroy Cluster (n=2): Kanawha Stemmed

Two Kanawha Stemmed points (Broyles 1966) were recovered from Dust Cave. Kanawha is one of many varieties of Early Archaic bifurcated base points. These points are small and triangular, “with a short, rounded and shallow bifurcated base” (Justice 1987: 95). Blades are straight to incurvate, with dramatically projecting shoulders. Many Kanawha specimens exhibit blade serration indicative of resharpening. Bases are notched or bifurcated and exhibit basal thinning scars but show no evidence for basal grinding. Stems are small, narrow and expanding, with rounded corners (Justice 1987: 95).

Kirk Stemmed Cluster (n=28): Kirk Stemmed, Kirk Serrated

Both the Kirk Stemmed (Coe 1964) and Kirk Serrated (Coe 1964; Cambron and Hulse 1969) types exhibit a long blade, often with deep edge serrations. Margins frequently are

recurvate and beveled, indicating resharpening of these tools. The major difference between the two types lies in the nature of their haft elements.

Kirk Stemmed points possess haft elements that were produced through a broad corner-notching technique that produced an expanding stem. The nature of the basal margin varies, and includes straight, slightly convex, and concave examples. Some Kirk Stemmed specimens exhibit slightly barbed shoulders.

Kirk Serrated points, on the other hand, exhibit straight-sided to slightly contracting hafts, with blunt-and-straight to thin-and-concave bases. Blade serration is especially robust on these specimens, cross-sections are plano-convex or biconvex, and shoulders are horizontal (Justice 1987: 82).

Eva Cluster (n=4): Eva

Eva points were described by Lewis and Lewis (1961) and include two variants (Eva I and Eva II) that are differentiated on the basis of their respective sizes and blade shapes. Eva I points are larger, with angular, recurved blade margins, while Eva II specimens are smaller, with straight or somewhat excurvate blades. In other respects, the two variants are essentially identical. Both were produced through a combination of percussion and pressure flaking, and received basal notching that created elongated shoulder barbs and a diminutive stem. Shoulder barbs among the Eva I specimens are squared or pointed and occasionally extended past the length of the stem, while the Eva II barbs are all pointed and often extend past the stem. Basal notches exhibit circular hertzian scars, and the diminutive stems exhibit straight, thinned basal margins (Justice 1987: 100).

Morrow Mountain Cluster (n=12): Morrow Mountain

Morrow Mountain points (Coe 1964) are relatively small, with broad trianguloid blades and wide, sloping shoulders. Coe (1964) identified two varieties, distinguished on the basis of their stem characteristics. Variety I points possess short, pointed, contracting stems, while Variety II specimens possess elongated, contracting stems (Justice 1987: 104-105).

White Springs Cluster (n=11): Sykes, Crawford Creek

At Dust Cave, two projectile point types were identified that belong to the White Springs Cluster: Sykes, and Crawford Creek. The latter is a morphological correlate of the White Springs cluster, defined by DeJarnette et al. (1962). Sykes points (Lewis and Lewis 1961) “are broad, short-stemmed forms with the haft element produced from the removal of the corners of a trianguloid perform” (Justice 1987: 108). Blade margins are excurvate to straight. Production of shallow “notches” creates a short stem and squared, sometimes slightly barbed, shoulders. The basal margin is straight, thick, and exhibits steep bifacial flaking.

Benton Cluster (n=58): Benton Stemmed, Buzzard Roost Creek

Benton Stemmed points (Kneberg 1956; Lewis and Lewis 1961) are large hafted bifaces that are characterized by the application of oblique-parallel flaking. This is a stemmed biface form, with a small, short, straight to expanding stem. Beveling is noted frequently on the base and in the stem notches, and occasionally on the blade. Beveling of the haft margins is bifacial and produces a flattened hexagonal cross-section.

Buzzard Roost Creek points (Cambron 1958a; DeJarnette et al. 1962; Cambron and Hulse 1975; Webb and DeJarnette 1948) are considered a morphological correlate of the Benton Cluster (Justice 1987: 112).

Ledbetter Cluster (n=4): Elora, Ledbetter, Pickwick

Ledbetter (Kneberg 1956; Bell 1960; Cambron and Hulse 1969) is “a contracting stemmed form with an asymmetrical blade” (Justice 1987: 149). Ledbetter points exhibit recurvature of the blade that is reversed on opposite margins, and unequal, barbed shoulders. The basal margin is straight, with no haft grinding apparent. Stems are short compared to the length of the blade and can be contracting to slightly expanding. Broad, random flaking of these specimens produced a biconvex cross-section.

Pickwick points (DeJarnette et al. 1962; Cambron and Hulse 1975) appear quite similar to Ledbetter points, but their recurved blades are notably more symmetrical. Shoulders are barbed and expanding, and cross-sections tend to be flattened to convex, often with a median ridge present. Basal margins are straight to convex (Justice 1987: 150-153).

Dickson Cluster (n=3): Gary Stemmed, Little Bear Creek

Gary Stemmed points (Newell and Krieger 1949) exhibit triangular blades and contracting stems. Blade edges are straight to slightly excurvate, with resharpening having altered edge margins of some specimens to incurvate or recurvate forms. Shoulders are wide and flaring. The stem contracts to a narrow, pointed or slightly rounded base. Haft margins generally are straight. The flaking pattern noted on these specimens tends to be irregular.

Little Bear Creek points (DeJarnette et al. 1962; Webb and DeJarnette 1948) “are medium to large with slightly excurvate blade edges and long stems” (Justice 1987: 196). These points are biconvex in cross-section, and exhibit horizontal to tapered shoulders. The haft exhibits a straight to contracting stem with lateral grinding. The basal margin is straight to convex, and can be thick and unmodified.

Probable Hafted Bifaces (PHB; n=64)

These pieces likely represent the same range of hafted biface implements described above, but they are fragmentary, thus preventing their definite assignment to the HAB category or to any particular type within that general category. These fragmentary specimens include basal/haft fragments, which are not easily assigned to one of the above cluster types, or identifiable haft types that lack blade elements. Without their blade elements intact, it is difficult to say with certainty whether the hafted piece possessed a projectile or knife blade, as opposed to a scraper blade, a drill bit, etc.

Bifacial Drills (Figure 4.2)

While various drill types have been identified in the Dust Cave assemblage, all are recognized by the presence of a long, narrow bit (Bit Length to Bit Width Ratio \bar{x} = 3.56; Table 4.10). The bifacial drill specimens, which tend to exhibit biconvex or diamond-shaped cross-sections, are the most common drills identified in the Dust Cave assemblage. They were produced almost exclusively of Fort Payne or Blue-Grey Fort Payne chert (89.8%), with only two specimens (5.1%) having been manufactured from Burlington chert. Three unifacial drill (perforator)

specimens were identified, and are discussed in the Flake Tools section, below. I have identified four sub-types of bifacial drills, in addition to a category of fragments.

Type I: Expanded Base Drill (n=6)

Expanded Base Drills exhibit tapered shoulders that expand quite dramatically from the narrow bit. The bases of these tools are wide ($\bar{x}=22.74$), compared to the width of their bits ($\bar{x}=10.36$), and are elongated. Basal elements include examples that taper slightly toward the proximal end, and more rectangular specimens with rounded proximal margins.

This category includes 1 relatively complete specimen, 2 medial fragments, 2 proximal fragments, and one refitted specimen (17061/17062).

Type II: Triangular (n=3)

These long, narrow, bifacially flaked tools exhibit straight lateral margins that expand evenly from tip to base. In other words, they do not exhibit the dramatic expansion in width noted near the basal portions of the Type I or III specimens. Basal margins are straight to mildly convex, and exhibit slightly rounded basal corners.

This category includes 2 relatively complete specimens and 1 proximal fragment.

Type III: T-Base Drills (n=3)

T-Base drills possess long, narrow, bifacially flaked bits. Their bases are short with acute or squared corners, and they expand dramatically from the narrow bits (Proximal Width $\bar{x}=21.99$; Bit Width $\bar{x}=10.65$). Shoulders are wide, and are tapered to horizontal.

This category includes 3 proximal fragments, with intact bases and snapped bits.

Table 4.10: Bit Length to Bit Width Ratio for Bifacial Drills. (Primary measurement data available in Appendix A, Table A-2.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BILENBIWID	8	2.45	4.76	3.5600	.90105
Valid N (listwise)	8				



Figure 4.3: Bifacial Drills. From left to right: Expanded Base Drill, Triangular Drill, T-Base Drill, Side-Notched Drill.

Type IV: Side Notched (n=1)

This single, relatively complete specimen possesses a long, narrow, bifacially flaked bit that expands slightly at the proximal end, where it meets narrow, acute shoulders. Basal morphology is identical to that described for Early Side-Notched projectile points (see above). Located below the remnants of narrow shoulders are wide, shallow, squared notches. The base exhibits broad, squared ears, a slight basal concavity, and basal thinning, but no grinding.

Fragments (n=25)

A total of 25 bifacial drill fragments were recovered, including 1 possible relatively complete specimen (with suspected damage to the proximal end), 12 distal/tip fragments, 10 medial fragments, and two proximal fragments. Several of the distal fragments represent only the very tip end of the drill bit, while the longer specimens may represent breaks closer to the haft end. The large number of fragmentary specimens compared to complete specimens in the sample suggests that these tools were quite prone to breakage as a result of their long, narrow, and rather delicate bits that may not have withstood the stresses applied during the heavy uses to which these tools were applied (see results of microwear analysis, Chapter 8).

Non-Biface Tools

Non-biface implements, discussed above, do not exhibit the characteristics that enable classification into the “biface” category. Most often these items are identified on the basis of a lack of flaking on two surfaces. The non-biface tools can be subdivided into two categories based on the presence or absence of flake characteristics. Tools that retain flake characteristics (e.g., distinctive dorsal and ventral surfaces, a bulb of percussion, a striking platform, etc.) can be

classified as “flake tools,” while implements that are not bifacial, but that also lack flake characteristics, are considered to be non-flake tools (may also be called “core tools”) (Andrefsky 2005: 77).

Cores and Core Tools (n=106; not examined for this study)

Cores are those items that exhibit evidence of flake removal or wear, but that do not correspond to either the biface or flake tool categories. While cores are used to supply blanks for the production of flake tools, core tools serve this same purpose in addition to being used as tools themselves (e.g., heavy cutting/chopping implements). In my typological scheme, I follow Andrefsky’s (2005: 80) definition and view cores “as a modified nucleus or mass of chippable stone rather than a tool with some particular kind of function.” Items that could be considered *core tools* have been relegated to other categories, such as Early-Stage Bifaces. While the flakes removed from these items could easily have served as blanks for further tool production (and likely did, considering the number of “biface flakes” identified in categories such as the Intentionally and Unintentionally Modified Flake tool classes), the fact that they exhibited the defining characteristics of bifaces suggests that flake production may not have been their primary or sole function. If the toolmaker’s sole purpose was to supply flakes for tool manufacture, he could achieve this goal through the production of other core types (e.g., blocky or amorphous cores) that required substantially less effort to produce.

Very few cores, as defined by Andrefsky, were found on the site. A total of 106 cores are noted in the original lithic tools catalog (Asa Randall, personal communication), although they were not measured or examined for the purposes of this dissertation. These include items identified during excavation and initial analysis, as well as several other specimens that were

identified during re-cataloging of the lithic tools at the beginning of this project. Core types noted on the site include primarily amorphous or expedient cores. Randall (2001) notes that dedicated expedient flake cores (i.e., those produced for the express purpose of deriving flakes that could be used in the execution of expedient or immediate tasks) are found in the greatest quantity in the Early Archaic levels. In addition to expedient, unstandardized flakes, it is clear that the Dust Cave toolmakers were producing specialized blades, although no blade cores were recovered from the site. Instead, examination of the flake tools indicates the use of blades in the Late Paleoindian and earliest Early Archaic. These blades were not produced from typical polyhedral cores, but instead appear to have been manufactured from specialized blade cores that were set up for the removal of single, large blades in a manner similar to the removal of flutes from Paleoindian projectile points (Meeks 1994: see also Morse 1969: 18). Meeks (1994) notes that, despite the lack of blade cores on site, some were recovered in other areas in Coffee Slough, near Dust Cave.

These items do not form a major part of this dissertation. The proximity of the Blue-Grey Fort Payne chert source to Dust Cave means that certain issues governing core technology may have been a minor concern to the inhabitants of the site. By this I mean that the technological concerns of the Dust Cave inhabitants can be partitioned into two aspects: those immediate technological concerns while stationed at the site, and those anticipated concerns for periods of activity away from the site. While stationed at Dust Cave, core technology may have been only of minimal importance to the inhabitants and toolmakers who had easy access to raw materials and, thus, who may not have concerned themselves with issues such as raw material conservation. While engaging in activities away from the site, specifically during other portions of the yearly settlement-subsistence cycle, toolmakers would have been forced to take into

account sources for the production of raw materials. Disparities in the location of raw material sources and the location of tool use could be mitigated by producing portable cores or suitable blanks while stationed at Dust Cave, and transporting these items while pursuing the remainder of the settlement-subsistence round. With a ready source of raw material available, though, it is quite likely that suitable blanks could have been selected from among the flakes produced even from random/amorphous cores. The exception to this is seen in the Paleoindian toolkit, which contained large numbers of tools produced on flakes derived from blade cores (see Blade Tools section, below). Some tools made from these sources may have been returned to the site and discarded as part of a gearing-up episode, while others may have been lost during the course of the settlement cycle.

While the cores themselves are not considered in great detail here, I am, nonetheless, concerned with these issues of core production within the larger settlement system. Taking into consideration what types of cores were being produced and what sorts of tools were being manufactured from their flake blanks can provide insight into the position that Dust Cave occupied within the larger technological cycle. Understanding that cycle provides another glimpse into the adaptive strategies of these early occupants of the Middle Tennessee Valley.

While the number of cores recovered from the site is not large, this is not a hindrance to my interpretations. Core types can be discerned from characteristics that remain on flakes and flake tool blanks. In my discussion of the various flake tool categories, below, I consider the proportions of various core types represented within each category. An examination of the core types from which blanks and tools were produced enables me to understand the range of technological decisions that were made in the design and production of the various tool categories.

Flake Tools (n=136)

The category of flake tools includes unifacial drills, gravers and perforators, various scrapers, general “unifaces,” and intentionally and unintentionally modified flake tools. These various sub-categories of flake tools are identified on the basis of the position and extent of the secondary modification applied to them. Some of these tools that have received substantial amounts of post-detachment modification appear much more formal than those pieces that received comparatively little investment in their manufacture. The majority of tools that received significant invasive modification fall into the “scraper” (complete dorsally flaked end scrapers; humpback scrapers; ovoid scrapers) and “general uniface” (complete dorsally flaked uniface fragments) categories.

Scrapers: End, Humpback, Ovoid, Side (n=70; Figure 4.3)

Scrapers are flake tools that exhibit “a steep edge produced by the removal of small flakes” (Andrefsky 1998: 73). The category can be further subdivided based on the location of the secondary flaking. In the Dust Cave assemblage, four sub-types of scrapers were identified: End, Side, Ovoid and Humpback. Each is described, below. With the exception of 5 specimens that were produced on unidentified materials, all others were manufactured of local Blue-Grey Fort Payne chert.

End Scrapers (n=43; 31 identifiable scrapers, 12 likely proximal fragments)

The end scrapers tend to be elongated specimens, moderate in size (see Tables 4.11 and 4.12), with relatively steep flaking (\bar{x} Bit Angle = 68.3°; Table 4.13) applied to the distal margin of the flake blank. This category of tools varies according to the amount of post-detachment

modification applied to the flake. Some received only marginal flaking to shape the bit or to modify the lateral margins, while others received substantial dorsal-lateral flaking that significantly modified the shape of the original blank.

In addition to those minimally flaked, marginally modified specimens discussed here, several others (n=11) were produced on true blades. Because of the very particular and extremely purposeful nature of the core preparation strategy necessary for producing blades, and because blade tools were so temporally restricted in the assemblage, I give these other specimens special consideration in the Blade Tools section, below. The remaining 11 minimally flaked end scrapers, produced on a variety of flake types, are considered here.



Figure 4.4: Scraper Types. From left to right: Dorsally Flaked End Scraper, Marginally Flaked End Scraper, Side Scraper, Ovoid Scraper, Humpback Scraper.

Table 4.11: Mean Length for End Scrapers. (Complete specimens only. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	25	25.65	65.09	40.3984	10.54197
Valid N (listwise)	25				

Table 4.12: Mean Width and Thickness for End Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	34	17.88	39.56	24.7935	4.42240
THICKNESS	34	3.77	21.88	8.6397	3.26895
Valid N (listwise)	34				

Table 4.13: End Scraper Bit Angles. (Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BIANG	29	57.5	85.0	68.362	7.6554
Valid N (listwise)	29				

Four of the minimally flaked specimens (Acc. Nos. 10387, 10843, 11408, 17615) were produced on narrow, elongated, blade-like flakes. While these scrapers had the overall outline morphology and, in some cases, the characteristic dorsal scar pattern associated with true blades, the nature of their platform preparation techniques differed from those of true blade cores. Each of these tools received only minimal post-detachment modification that was restricted to the tool margins. Marginal modification and their production on elongated flakes are the only commonalities among this category; in other respects, these tools are quite variable.

Of these four specimens, two (Acc. Nos. 10843, 11408) exhibited teardrop-shaped outlines, but differed in their other characteristics. Specimen 11408 possessed a clear stem portion at the proximal end, delimited by very weak shoulders. Specimen 10843 was relatively thick and exhibited a triangular cross-section and no marginal flaking.

The remaining two of the minimally flaked scrapers on blade-like flakes were parallel-sided, but otherwise dissimilar. Specimen 10387 is thin with lateral flaking, and specimen 17615 was very thin with marginal flaking that is ephemeral enough that it may not have been applied purposefully.

Five other minimally flaked end scraper specimens appear to have been produced on flakes derived from multidirectional objective pieces including, but not limited to, biface cores (Acc. Nos. 10363, 11462, 11566, 13648, 13658). These pieces are quite variable in size and shape and include a specimen from one of the Paleoindian levels (Zone T) that was produced to look like the more formal, “spurred,” triangular, dorsally flaked end scrapers discussed below. The remaining cases included a heat-damaged scraper with a graver spur and rounded bit end, produced from a multidirectional core blank; two small, trianguloid, marginally flaked “thumbnail” scrapers; a larger, thick, amorphous, marginally flaked specimen; and a weak-shouldered, stemmed scraper with marginal flaking restricted to the shoulder region.

One Late Paleoindian (Acc. No. 10936; Zone U) end scraper specimen was produced on what appears to have been a decortication flake, as the dorsal surface was completely covered in cortex. Only the lateral and distal margins received any secondary flaking. This tool, which resembles minimally flaked Paleoindian trianguloid end scrapers (e.g., Gramly 1982, MacDonald 1968) exhibited contracting lateral margins, “spurs” on the corners of the bit, and a steep, flat bit margin.

One broken, minimally flaked end scraper specimen (Acc. No. 14645) was identified. This piece appears to have been produced on a flake derived from multidirectional core and was too fragmentary to allow classification into one of the sub-categories described above. Recognition of this tool as a “scraper” was based on the presence of steep flaking on the distal margin.

The specimens that fall within the “complete dorsally flaked” category (n=16; Acc. Nos. 10279, 10294, 10326, 11427, 11430, 11438, 11508, 11519, 11543, 11557, 13895, 13903, 17879, 17922, 17841, 17939) exhibit flaking all over the dorsal surface of the blank, presumably as a means of producing and/or refining the outline morphology and component measurements (e.g., haft measurements). The dorsally flaked specimens, themselves, fall into several categories based on their outline morphology and include teardrop-shaped, stemmed, and humpback specimens.

The teardrop-shaped, dorsally flaked end scrapers (n=12; Acc. Nos. 10279, 10326, 11427, 11430, 11438, 11508, 11557, 13895, 17879, 17922, 17841, 17939) taper dramatically from the bit end to the base/haft, becoming almost pointed at the proximal end of the tool (see Table 4.14). They are long and narrow with plano-convex cross sections and are either flat or exhibit slight ventral curvature in longitudinal section. Nearly all of the teardrop-shaped specimens exhibit parallel-collateral dorsal flaking that, in some cases, produced a distinct median ridge. This dorsal flaking is highly patterned, suggesting very careful and intentional application. These tools correspond to items recovered from Early Archaic contexts in Eastern North America (see Daniel 1998; McMillan 2003).

The remaining four complete dorsally flaked specimens (Acc. Nos. 10294, 11519, 11543, 13903) are fragmentary.

Two specimens are classified as stemmed scrapers (Acc. Nos. 11494, 17034), although one of the humpback specimens also possessed a stem. These scrapers exhibit slightly contracting stems with straight bases and slightly contracting blades with mildly convex, steep, finely flaked bits. Bifacial flaking is seen on the stem and toward the proximal end of the blade. These stemmed scrapers exhibit plano-convex cross-sections and are relatively flat in longitudinal section.

Table 4.14: Width Measurements for Teardrop-Shaped End Scrapers. (Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	12	17.88	29.22	24.5600	3.87659
PROXWID	12	7.08	20.43	14.7950	3.90650
PLATWID	6	1.89	5.65	3.7583	1.49651
Valid N (listwise)	6				

In addition to the complete and relatively complete specimens discussed above, several end scraper fragments have been identified (n=12; Acc. Nos. 10349, 10509, 10930, 11387, 11464, 11500, 11503, 11544, 11590, 13711, 13889, 13929). Two distal/bit fragments that exhibit highly patterned complete dorsal flaking were recovered from the Paleoindian levels (Zone T). Because these specimens are distal fragments, it is impossible to say for certain whether they conform to the teardrop shaped end scraper description provided above. Twelve other specimens likely represent proximal portions of these same teardrop-shaped, completely dorsally flaked Late Paleoindian/Early Archaic end scrapers. These proximal fragments were recovered from Zones R and T. They taper toward pointed proximal ends and exhibit highly patterned, complete dorsal flaking that produced plano-convex cross-sections. In light of the nature of the flaking

applied to these tools, as well as their provenience, I feel quite confident in assigning them to the Late Paleoindian/Early Archaic teardrop-shaped end scraper category.

Another fragmentary specimen exhibits unpatterned dorsal flaking and received too much thermal damage to allow classification based on its morphological or technological characteristics. One final fragmentary end scraper specimen, represented only by its distal portion, was quite narrow and thin, with flaking restricted to the distal end (i.e., no modification of the lateral margins). Dorsal flaking was apparent on this specimen, but exhibited little patterning.

Humpback Scrapers (n=5):

The category of humpback end scrapers includes specimens that are extremely thick at the distal end (\bar{x} =18.07 mm; see Table 4.16 – compare to measurements for other sub-types in Tables 4.12, 4.18, and 4.21) and taper toward the considerably thinner proximal end. This category includes 5 specimens, one of which tapers laterally toward the proximal end, while the other two appear stemmed. Because of the particular appearance of their longitudinal cross-sections, though, I include these latter specimens in the “humpback” rather than “stemmed” category. All three specimens display pronounced bulbs of percussion on the ventral surface and all exhibit slight ventral curvature in longitudinal section. All are dorsally flaked, but none exhibit the careful flake patterning noted among the teardrop-shaped specimens. Some of the humpback specimens are large enough that they might have been hand-held.

Table 4.15: Mean Length for Humpback Scrapers. (Complete specimens only. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	4	48.90	73.53	57.9050	11.17654
Valid N (listwise)	4				

Table 4.16: Mean Width and Thickness for Humpback Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	5	25.79	63.79	35.8120	15.83808
THICKNESS	5	12.34	32.76	18.0720	8.35438
Valid N (listwise)	5				

Ovoid Scrapers (n=11)

These scrapers are ovoid in outline morphology and exhibit secondary flaking around the entire circumference of the artifact. These tools are fairly large and thin (see Tables 4.17 and 4.18) and exhibit working edge angles that are more acute than those seen on the end scrapers ($\bar{x}=60.3^\circ$; see Table 4.19).

Two sub-categories were identified. The first group comprises very large specimens with ovate to teardrop-shaped outlines and extensive dorsal flaking. Of these dorsally flaked specimens, several were produced on blades and will be discussed in the descriptions of specialized blade tools, below. All of these specimens exhibit extensive dorsal-lateral flaking, with parallel-collateral or convergent flake scars. Finer secondary flaking was then applied to the margins in order to produce useable edges around the entire circumference of the tool. Each of the ovoid scrapers exhibits fairly pronounced ventral curvature, and their cross sections are plano-convex to slightly triangular.

Table 4.17: Mean Length for Ovoid Scrapers. (Complete specimens only. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	10	49.49	88.35	67.2280	14.14135
Valid N (listwise)	10				

Table 4.18: Mean Width and Thickness for Ovoid Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	11	26.33	52.31	36.2155	9.55113
THICKNESS	11	6.14	20.32	12.2964	4.98353
Valid N (listwise)	11				

Table 4.19: Edge Angle for Ovoid Scrapers. (Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BIANG	8	50.0	70.0	60.313	6.4694
Valid N (listwise)	8				

The second group of ovoid end scrapers was modified only marginally. These specimens are more variable than the completely dorsally flaked scrapers described above. The unifying characteristic is the presence of secondary flaking around the perimeter of the piece. These scrapers were produced from decortication flakes, biface flakes, and flakes from blocky cores. Cross sections included plano-convex, flattened, and trapezoidal examples. One specimen (Acc. No. 13912) appears to have been a multifunctional uniface, exhibiting an apparent steep end scraper margin along the distal end of the flake, as well as a graver spur.

Side Scrapers (n=11)

These relatively large (see Tables 4.20 and 4.21), unifacially flaked tools possess at least one modified lateral margin. They exhibit no modification of the distal margin and, in contrast to the ovoid scrapers, the secondary flaking does not extend around the entire circumference of the piece. Edge modifications produced edge angles that were more acute than those observed for end scrapers, and more similar to the ovoid scraper specimens (see Table 4.22).

One sub-category of side scrapers – those produced on large blades – will be considered below in the discussion of specialized blade tools. The remaining side scrapers identified in the Dust Cave assemblage exhibit variable characteristics. Many of these specimens are long and narrow and exhibit parallel, expanding, concave, convex, or recurvate margins. One specimen received bifacial marginal flaking, while the others were flaked only unifacially. Cross sections included plano-convex and triangular examples. One specimen (Acc. No. 17669) received complete dorsal flaking, like the class of end scrapers described above. While this single implement exhibits a convex distal end, this margin received no distinct modification and the edge angle is acute, suggesting that it is not a member of the dorsally-flaked end scraper category. Instead, modification is restricted to the lateral margins.

Table 4.20: Mean Length for Side Scrapers. (Complete specimens only. Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	6	46.07	86.61	68.1300	15.71394
Valid N (listwise)	6				

Table 4.21: Mean Width and Thickness for Side Scrapers. (Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	9	24.70	60.82	36.7233	11.25132
THICKNESS	9	5.16	20.87	10.1700	4.57202
Valid N (listwise)	9				

Table 4.22: Edge Angles for Side Scrapers. (Primary measurement data available in Appendix A, Table A-3.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BIANG	8	45.0	77.5	61.875	10.4155
Valid N (listwise)	8				

Perforators (n=6; Figure 4.4)

Flake perforators are identified by the presence of a narrow, elongated, protruding bit along one margin of the tool. The distinction between drills and perforators rests on the length of the bit. Drills exhibit long, narrow bit ends, while perforators possess smaller, shorter projections. The mean bit length to bit width ratio for perforators is 2.73 (see Table 4.23), compared to 3.56 for bifacial drills (see Table 4.10). All specimens were manufactured of Fort Payne or Blue-Grey Fort Payne chert.

I have identified two sub-types of flake perforators in the Dust Cave assemblage.

Type I Perforators (n=5)

This category contains all but one of the identified flake perforator specimens. This generalized category includes unifacial implements with narrow, thin, projecting bit ends that are shorter than those identified as “drills” but longer and thinner than those classified as “gravers.” These

five specimens were produced on flakes derived from a variety of core types, and exhibit no patterning in shape, size or thickness. Each specimen possesses a single perforator projection. While most examples are relatively small and thin, one specimen (Acc. No. 10411) is large, thick, and parallel-sided.

Type II Perforators (n=1)

This single specimen (Acc. No. 10908) represents the only example of a multipurpose scraper/perforator. It exhibits a steeply flaked end scraper bit opposite the steeply flaked and projecting perforator bit. This specimen, recovered from Zone T (Late Paleoindian) exhibits bidirectional flaking on the dorsal surface and may have been derived from a blade core. The lack of an intact platform, though, makes this interpretation merely conjectural. It is possible that this specimen represents an end scraper that was broken and subsequently reworked into a perforator. It is large enough, though, that it could have continued to function as a hand-held scraper.

Gravers (n=13; Figure 4.5)

Gravers (also called “burins”; see Andrefsky 2005) are flake tools that exhibit small, generally fairly thick protuberances along one or more margins. These protuberances tend to be smaller and thicker (Table 4.24) than the projections on perforators, discussed above (Table 4.23). While the difference appears minor (approximately 1 mm), they are dramatically thicker when considered in relation to their much shorter bits (on average only 1.47 times as long as they are wide, compared to perforator bits, which are nearly 3 times as long as they are wide). The



Figure 4.5: Perforators.

Table 4.23: Bit Length to Bit Width Ratio for Perforators. (Primary measurement data available in Appendix A, Table A-2.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BILENBIWID	3	2.04	3.90	2.7333	1.01633
Valid N (listwise)	3				

heavier, thicker bits suggest their use in activities that involved the application of significant amounts of pressure that would crush the finer perforator bits. Generally, gravers are considered to be wood- or bone-working tools used to engrave these harder materials (Andrefsky 2005: 161-162, 254, 256; Odell 2003: 106).

The seven specimens identified as gravers can be divided into four sub-type categories.

Type I Gravers (n=3)

These three specimens are classified as “single gravers”. They are made on a variety of flake types, but all exhibit a single short, thick, steeply flaked spur on one margin.

Type II Gravers (n=1)

This single specimen was produced on a thin, expanding, biface thinning flake and exhibits secondary modification along the dorsal left and right margins. The distal end is straight but possesses a short, thick, very steeply flaked protuberance in the middle of the distal margin. The morphology of this piece is reminiscent of modern wood spade/paddle drill bits.

Table 4.24: Mean Bit Length to Bit Width Ratio for Gravers. (Primary measurement data available in Appendix A, Table A-2.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BILENBIWID	7	.74	2.13	1.4743	.60077
Valid N (listwise)	7				



Figure 4.5: Gravers. (Note: third specimen from the left is a combination Scraper/Graver.)

Type III Gravers (n=2)

Members of this category are identified by the presence of two short, thick, steeply flaked graver spurs on each tool. The two specimens classified as Type III were produced on flakes from multidirectional/amorphous cores. On one specimen (Acc. No. 11429), both spurs were located near one another on the same margin, while on the other piece (Acc. No. 10364) the spurs were located on separate margins.

Type IV Gravers (n=1)

Only one specimen was identified as a combination scraper/graver. This single specimen (Acc. No. 11569) was produced on a thick, nearly parallel-sided blank. The graver spur is

located on one lateral margin near the distal end of the flake. The opposite margin received steep secondary modification that resembles side scraper margins.

General Unifaces (n=47)

This final category of flake tools is a catch-all category for unifacially flaked specimens that either could not be classified because their particular morphological characteristics did not match the requirements for inclusion in one of the above described categories or that represent unclassifiable fragments of unifacial specimens. The general uniface category can be subdivided into four classes: Multi-Edged, Single-Edged, Complete Dorsal Flaking, and Other. With only 5 exceptions (all unidentified materials), all of the General Unifaces were produced from Fort Payne or Blue-Grey Fort Payne chert. Primary measurement data for the Unifaces can be found in Appendix A, Table A-4.

Type I (n=10): Multi-Edged Unifaces.

These fragmentary specimens exhibit secondary flaking along more than one margin. Three general classes of outline morphology are noted within this category: rectangular/parallel-sided, contracting, and amorphous/miscellaneous.

Type II (n=16): Single-Edged Unifaces.

These specimens exhibit secondary flaking along only one margin. Several edge morphologies are noted among the Type II unifaces, including straight, convex, concave, and undulating. The undulating specimens exhibit “saw-toothed” edges with teeth that are too broad and too rounded to represent serration.

Type III (n=17): Complete Dorsal Flaking.

The Type III category includes specimens that exhibit secondary flaking all over the observable dorsal portion of the fragments. Thirteen of these pieces are contracting or pointed in outline morphology and likely represent the fragmentary proximal or haft ends of the complete dorsally flaked end scrapers, described above. The remaining four specimens are dorsally flaked medial and lateral fragments whose origins are less easily assessed.

Type IV (n=4): Other.

This final sub-category is a catch-all for any other unifaces that do not correspond to the above descriptions. Three are lateral fragments, and the fourth may represent the broken distal portion of an end scraper. This assessment is conjectural, though, as the piece sustained such significant thermal damage that it is impossible to determine whether the steep “bit end” actually represents a steeply flaked end scraper bit.

Three other marginally modified unifaces were produced on blades and will be considered in my discussion of blade tools, below.

Intentionally Modified Flakes (n=149)

The category of Intentionally Modified Flakes – sometimes called “retouched flakes” – comprises a total of 149 specimens, including 28 complete, 21 relatively complete, and 80 fragmentary specimens. The remaining 20 cases are ones that I was unable to locate in the collection. While some researchers refer to these tools as “retouched flakes” I prefer to use the term “Intentionally Modified Flakes” in order to avoid confusion between the dual meanings of

the word “retouch.” Retouch can refer either to post-detachment modification that is applied to a tool blank in order to produce appropriate edge characteristics for tool use (i.e., edge shape, edge angle) *or* to rework/resharpen an edge that has been broken or dulled through use. According to my definition, the former represents *intentional modification*, while the latter may be classified as *retouch*.

These items tend to be produced and utilized in an expedient or opportunistic manner. The toolmaker/user, who is engaged in a particular task, identifies a flake that is largely suitable for executing the immediate task requirements and modifies it in such a way as to tailor its characteristics to the task at hand. For example, the edge morphology may be altered or flaking may be applied to modify the angle of the working edge. These tools are not formal, are not hafted, and are unlikely to have been curated. We expect that they were abandoned once the task was completed, rather than being transported to another site for continued use. As such, they provide a snapshot of the activities, other than stone tool production, that occurred on a site.

Intentionally Modified Flakes are identified on the basis of (a) their retention of original flake blank characteristics, which distinguish them from bifacial or core tools and (b) by the presence of secondary flake scars, generally larger than 2 mm in size, applied in a patterned fashion to one or more of the edge margins. This flaking tends to be continuous along at least a portion of the flake margin, and produces a distinct edge shape (e.g., concave, convex, straight, serrated/denticulate).

Examination of the remaining flake blank characteristics provides insight into the nature of the cores or objective pieces from which these blanks were derived. This is especially useful for interpretations of technological strategies at sites like Dust Cave where very few examples of cores were recovered.

The collection of intentionally modified flake tools was produced from flakes derived from a variety of core types. Proportions of various identified core types are as follows: 34 probable amorphous (22.8%); 19 blade/blade-like (12.8%); 16 blocky (10.7%); 11 probable biface (7.4%); 2 probable bipolar (1.3%); 3 nodular (2.0%); 64 unidentified (43.0%). With the exception of one flake produced from chalcedony and one flake produced from an unidentified coarse grey chert (perhaps Tuscumbia limestone chert), all of the intentionally modified flake tools were produced from variants of Fort Payne chert, including Fort Payne, Blue-Grey Fort Payne and Fort Payne Fossiliferous.

A consideration of edge morphology provides insight into the functional roles of these implements. By far the most common edge configuration is straight (n=66; 44.3%), followed by convex (n=28; 18.8%), concave (n=16; 10.7%), serrated (n=9; 6.0%), recurvate (n=4; 2.7%), denticulate (n=3; 2.0%), and undulating (n=3; 2.0%). Twenty specimens (13.4%) were not recorded. The large number of straight edges suggests to me the application of these tools to fairly generalized purposes. Little emphasis was placed on producing activity- or task-specific tool margins, unlike those seen among some of the more formal implements. A straight edge, much like a knife blade, could be utilized for a variety of purposes. The functions to which these tools were put are assessed in Chapter 8.

The collection of Intentionally Modified Flake specimens produced a mean length of 51.36 (complete specimens only), a mean width of 34.75, and a mean thickness of 11.68 (see Tables 4.25 and 4.26). These tools exhibit a moderate mean edge angle of 62.1°, and a mean modified edge length of 35.46 mm.

Table 4.25: Mean Length for Intentionally Modified Flakes. (Complete specimens. Primary measurement data available in Appendix A, Table A-5.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	49	21.13	88.47	51.3555	16.87273
Valid N (listwise)	49				

Unintentionally Modified Flakes (n=555)

The category of Unintentionally Modified Flakes – sometimes also called “Utilized Flakes” – comprises a total of 555 specimens, including 121 complete, 53 relatively complete, and 135 fragmentary. The remaining 245 specimens were not selected for intensive observation and measurement (the selection process is discussed in Chapter 5). I have opted to use the term “Unintentionally Modified Flake” rather than “Utilized Flake” because plenty of other tools are produced on flakes and are utilized, including the Intentionally Modified Flakes discussed above, as well as unifacially flaked implements. The term “Unintentionally Modified Flake” identifies this implement as a flake that was selected and utilized expediently or opportunistically, without any application of secondary modification in order to alter the angle or morphology of the intended working edge. A sharp, unmodified flake could easily be used to cut a piece of meat, sinew, or plant fiber; as long as it is sharp, it can fulfill a range of simple functions.

Table 4.26: Mean Width and Thickness for Intentionally Modified Flakes. (All specimens. Primary measurement data available in Appendix A, Table A-5.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	129	8.88	76.13	34.7496	13.39570
THICKNESS	129	2.41	27.99	11.6808	5.10875
Valid N (listwise)	129				

These implements became modified not through manufacture, but through use. Small flakes, generally less than 2 mm in size, are removed from tool margins as a result of working various materials, particularly those categorized as medium or hard. The worked material essentially acts as a pressure flaker, removing tiny flakes from the thin flake edges. The production of this sort of microchipping will be discussed in greater detail in Chapter 6.

A consideration of the raw material types used in the production of these unintentionally modified flakes indicates that most were produced from variants of Fort Payne chert, including Fort Payne and Blue-Grey Fort Payne (n=305; 97.1%). The remainder of the sample was produced from various materials, including an unidentified white chert (n=6; 1.9%), an unidentified black chert (n=2; 0.6%), and chalcedony (n=1; 0.3%).

These specimens were produced on a variety of core types. Of the 300 specimens for which blank/core type was available, 26.7% (n=80) were produced from amorphous cores, 23.3% (n=70) from biface cores, 18.3% from cobble/nodular cores, 5.3% (n=16) from blade/blade-like cores, and 0.3% (n=1) from a piece of angular shatter. The types of cores used in the production of the remaining 60 specimens were unidentifiable.

Given that several of these specimens exhibit use on more than one edge margin, edge morphology was recorded per tool edge, rather than per tool. The majority of tool margins were straight (n=218; 60.6% of edges examined), but examples of concave (n=54; 15%), convex (n=54; 15%), undulating (n=23; 6.4%), serrated (n=5; 1.4%), recurvate (n=4; 1.1%) and pointed (n=2; 0.6%) margins were also observed. It is important to recall that edge morphology was not altered through intentional modification in these cases; these tools were being selected for having sharp, usable edge margins that were already an appropriate shape for their intended use. The even higher proportion of straight edge margins among the Unintentionally Modified specimens,

compared to the Intentionally Modified Flakes considered above, suggests an even greater emphasis on the selection of very generalized forms for the opportunistic completion of tasks. For example, a straight, sharp margin would make a very efficient one-time-use cutting implement.

Mean utilized edge length of the Unintentionally Modified Flakes (32.6 mm) is slightly shorter than the modified edge lengths for the Intentionally Modified Flake implements (see above). Slightly shorter utilized edge length may be related in part to the smaller overall length of these implements, compared to the Intentionally Modified Flakes. Mean length for the complete specimens is 47.38 mm (Table 4.27). Mean width and thickness measurements are closer to those of the Intentionally Modified Flake implements, measuring at 34.77 mm and 9.17 mm, respectively (Table 4.28).

Table 4.27: Mean Length for Unintentionally Modified Flakes. (Complete specimens. Primary measurement data available in Appendix A, Table A-6.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	174	15.99	97.78	47.3772	13.96662
Valid N (listwise)	174				

Table 4.28: Mean Width and Thickness for Unintentionally Modified Flakes. (All specimens. Primary measurement data available in Appendix A, Table A-6.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	314	11.06	81.33	34.7653	12.81036
THICKNESS	314	1.95	26.92	9.1675	4.98950
Valid N (listwise)	314				

Specialized Blade Tools (n=85)

Blades and tools produced from blades are common in the Late Paleoindian and Early Archaic assemblages at Dust Cave. Blades have traditionally been defined as a type of flake that possesses parallel or sub-parallel lateral margins and that is at least twice as long as it is wide (Bordes 1961). It is possible, though, to produce flakes that exhibit these characteristics without their production being intentional. Typically, true blades are produced from specially prepared, polyhedral cores that are set up in such a way as to permit consistent flake removals, generally in a unidirectional manner. Flakes are removed from a single, prepared striking platform and are detached so that the applied force follows the ridges left from previous blade removals, which produces triangular or trapezoidal cross-sections (Collins 2002; Crabtree 1972). Blades can be used without modification or can be modified into a variety of specific tool forms (e.g., knives, scrapers, etc.). The blade cores used in the Dust Cave technology, however, do not appear to represent specimens that were struck from polyhedral cores. Instead, these large blades seem to correspond to a core type defined by Morse (1969: 18), which has been recognized in Arkansas and seems to correspond to Paleoindian fluting techniques:

A striking platform on one end of a rectangular to oval core was carefully prepared and the blade detached. The core was either discarded or more usually modified into a gouge, wedge, or adz. It is easily recognized because of the central blade scar and a beveled, ground, and battered striking platform.

These blade cores were produced for the purpose of driving off a single, large blade.

Blade Scrapers (n=18)

The category of Blade Scrapers includes 18 specimens: 11 end scrapers, 3 side scrapers, and 4 unidentified scraper fragments. Nearly all of these tools were produced on Blue-Grey Fort Payne chert, with the exception of two specimens produced on a probable Fort Payne variant (tan

colored). Scraper categories were differentiated on the basis of the location of secondary flaking in order to produce the working edge/bit. End scrapers received secondary flaking along the distal margin, while side scrapers were modified along one or both lateral margins. Occasionally, secondary flaking was also applied to the lateral margins of end scrapers, but overall these specimens were flaked only minimally.

Of the 11 end scrapers, 6 are complete/relatively complete and 5 are fragmentary. All three of the side scraper specimens are fragmentary. Most of the blade scrapers are “non-formal,” meaning that they required or received very little post-detachment modification in order to achieve the desired outline morphology. Only three of the end scraper specimens were categorized as “formal,” having received more post-detachment modification in the form of secondary flaking that extended past the lateral tool margins onto the tool surface. One of these appears to have been a typical Late Paleoindian trianguloid end scraper (likely hafted), complete with “spur” on the bit corner (see Gramly 1982, MacDonald 1968). While blades are often defined as being twice as long as they are wide, the length to width ratio of the blade end scrapers suggests that distal modification may have removed at least some of the length of the original blanks (\bar{x} Length to Width ratio = 1.69, complete specimens only). These tools were relatively thin, with an average width to thickness ratio of 4.91.

Very little can be said about the side scrapers, with only three specimens having been identified and only one of these being complete. The single complete specimen (Acc. No. 17113) was relatively long (62.56 mm) but was very wide in comparison to its length (83.28 mm). Despite these strange proportions, the platform and dorsal characteristics all indicated that this specimen was produced on a blade.

The side scraper examples were even thinner than the end scrapers, exhibiting an average width to thickness ratio of 5.71 (Table 4.34). I suggest that the use of thicker blanks in the production of end scrapers, compared to the thinner blanks used in production of side scrapers, may provide some insight into differences in the intended functions of these two tool classes. The thicker end scrapers may have been subjected to more intensive bending loads – a combination of compressive and tensile stresses – that could cause the tool to snap near the midpoint, or near the juncture between blade and haft. Thicker specimens may have been more resistant to these stressors.

Unmodified Blades and Other Blade Tools (n=67)

The remaining blade implements are discussed here, including unmodified blades (blanks) and both Intentionally and Unintentionally Modified Blade tools.

Unmodified Blades (n=19)

The category of unmodified blades includes 19 specimens: 8 complete/relatively complete and 11 fragments. These blanks tend to be relatively large (mean length: 70.13; mean length to width ratio: 2.7; see Tables 4.35 and 4.37) and fairly thin compared to their widths (see Table 4.36; mean width to thickness ratio: 3.9, see Table 4.38).

Table 4.29: Mean Length for Blade End Scrapers. (Complete specimens. Primary measurement data available in Appendix A, Table A-7.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	6	36.43	68.06	48.1517	11.59444
Valid N (listwise)	6				

Table 4.30: Mean Width and Thickness for Blade End Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-7.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	11	26.85	40.24	31.0718	4.74683
THICKNESS	11	4.82	8.23	6.5636	1.14872
Valid N (listwise)	11				

Table 4.31: Mean Length to Width Ratio for Blade End Scrapers. (Complete specimens. Primary measurement data available in Appendix A, Table A-7.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENWID	6	.95	2.53	1.6883	.54223
Valid N (listwise)	6				

Table 4.32: Mean Width to Thickness Ratio for Blade End Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-7.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTHK	11	3.26	7.96	4.9073	1.36865
Valid N (listwise)	11				

Table 4.33: Mean Width and Thickness for Blade Side Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-7.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	3	36.75	83.28	54.8933	24.89889
THICKNESS	3	6.42	13.66	10.3967	3.67233
Valid N (listwise)	3				

Table 4.34: Mean Width to Thickness Ratio for Blade Side Scrapers. (All specimens. Primary measurement data available in Appendix A, Table A-7.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTHK	3	2.69	7.50	5.7133	2.63269
Valid N (listwise)	3				

Intentionally Modified Blades (n=28)

The category of Intentionally Modified Blades includes 28 specimens: 13 complete/relatively complete and 15 fragments. Of these 28 pieces, all were produced from either Blue-Grey Fort Payne chert or other Fort Payne variants. The Intentionally Modified Blade specimens are large (mean length: 81.22 mm; mean length to width ratio: 2.2; see Tables 4.39 and 4.41) and fairly thin (mean thickness: 9.35 mm; mean width to thickness ratio: 3.9; see Tables 4.40 and 4.42). Edge modification produced an overall mean edge angle of 55.3° (see Table 4.44), which is relatively acute compared, for example, to the mean edge angle for the various end scraper forms discussed above. Edge angles are more similar to side scraper angles (see above). Working edge lengths for these Intentionally Modified Blade tools average 49.24 mm. (see Table 4.43).

Table 4.35: Mean Length for Unmodified Blades. (Complete specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	8	48.23	85.96	70.1250	11.02826
Valid N (listwise)	8				

4.36: Mean Width and Thickness for Unmodified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	19	10.08	42.50	25.5595	9.90569
THICKNESS	19	2.59	11.97	6.7447	2.72823
Valid N (listwise)	19				

Table 4.37: Mean Length to Width Ratio for Unmodified Blades. (Complete specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENWID	8	2.02	3.99	2.6662	.76511
Valid N (listwise)	8				

Table 4.38: Mean Width to Thickness Ratio for Unmodified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTHK	19	2.25	5.73	3.9053	.94465
Valid N (listwise)	19				

Table 4.39: Mean Length for Intentionally Modified Blades. (Complete specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	13	40.16	142.55	81.2185	26.99308
Valid N (listwise)	13				

Table 4.40: Mean Width and Thickness for Intentionally Modified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	28	19.96	50.53	32.4346	8.15820
THICKNESS	28	4.45	22.14	9.3521	4.54505
Valid N (listwise)	28				

Table 4.41: Mean Length to Width Ratio for Intentionally Modified Blades. (Complete specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENWID	13	1.67	3.50	2.1992	.53795
Valid N (listwise)	13				

Table 4.42: Mean Width to Thickness Ratio for Intentionally Modified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTHK	28	1.81	7.36	3.9032	1.35262
Valid N (listwise)	28				

Table 4.43: Mean Working Edge Lengths for Intentionally Modified Blades. (Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WEDGLENL	26	10.00	105.00	54.8077	26.99929
WEDGLENM	4	20.00	65.00	46.2500	20.56494
WEDGLENR	24	15.00	120.00	46.6667	25.98773
Valid N (listwise)	4				

Table 4.44: Mean Width to Thickness Ratio for Intentionally Modified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WEDGANGL	26	40.00	72.50	55.1923	8.15239
WEDGANGM	4	43.00	58.00	53.0000	7.07107
WEDGANGR	24	42.50	72.50	57.8125	7.98479
Valid N (listwise)	4				

Unintentionally Modified Blades (n=20)

The Unintentionally Modified Blade category comprises a total of 20 specimens: 15 complete/relatively complete and 5 fragmentary. All 20 of these tools were produced from Blue-Grey Fort Payne chert. These implements are smaller, overall, than the Intentionally Modified specimens, with a mean length of 67.26 (Table 4.45) and a mean length to width ratio of 2.6 (Table 4.47). These implements are thinner than their Intentionally Modified counterparts as well (mean width to thickness ratio: 4.2; Tables 4.46 and 4.48). Surprisingly, in spite of the smaller overall size of these blades, their working edge lengths are not markedly different from those of the Intentionally Modified Blades (mean length: 50.86 mm; Table 4.49). These tools, which received only unintentional modification, also exhibited working edge angles quite similar to those of the intentionally modified variety (mean 51.7°; Table 4.50). The similarity in working edge angle, in particular, may speak to the intended function of these blade implements, as well as to the standardization that could be achieved in their production. These issues will be considered in greater detail in Chapter 8, where the results of the microwear analysis on these specimens are presented.

Table 4.45: Mean Length for Unintentionally Modified Blades. (Complete specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENGTH	15	40.91	87.60	67.2593	14.33295
Valid N (listwise)	15				

Table 4.46: Mean Width and Thickness for Unintentionally Modified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTH	20	13.86	48.92	27.4780	8.84966
THICKNESS	20	4.38	12.50	6.7470	2.05384
Valid N (listwise)	20				

Table 4.47: Mean Length to Width Ratio for Unintentionally Modified Blades. (Complete specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LENWID	15	1.77	4.69	2.5827	.70887
Valid N (listwise)	15				

Table 4.48: Mean Width to Thickness Ratio for Unintentionally Modified Blades. (All specimens. Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WIDTHK	20	2.47	9.04	4.2410	1.51495
Valid N (listwise)	20				

Table 4.49: Mean Edge Lengths for Unintentionally Modified Blades. (Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WEDGLENL	13	30.00	85.00	51.9231	15.21217
WEDGLENM	1	55.00	55.00	55.0000	.
WEDGLENR	15	20.00	95.00	45.6667	22.74601
Valid N (listwise)	1				

Table 4.50: Mean Edge Angles for Unintentionally Modified Blades. (Primary measurement data available in Appendix A, Table A-8.)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
WEDGANGL	13	37.50	72.50	54.2308	8.44002
WEDGANGM	1	45.00	45.00	45.0000	.
WEDGANGR	15	42.50	77.50	55.8333	9.57427
Valid N (listwise)	1				

CONCLUSION

This chapter has presented the typological scheme developed for the Dust Cave lithic assemblage and has presented definitions of the various tool classes considered in this dissertation. The following chapter presents the methods used in collection and assessment of the lithic data from Dust Cave. These methods are directed at interpreting both the technological and functional characteristics of these tools. A discussion is given of the attributes studied and how those attributes can inform analysts of the technological decisions that were made in the selection, production, use, and even discard of stone tools. Chapter 6 presents an overview of the foundations and techniques of microscopic use wear analysis, which provides the basis for the functional interpretations in Chapter 8.

CHAPTER 5: METHODS – TECHNOLOGICAL ANALYSIS

This chapter presents the methods employed for collecting and analyzing technological data from the Dust Cave lithic assemblage, including the technological attributes that were recorded, and how those attributes contribute to interpretations of design considerations and technological strategies. These analyses, when considered within the framework of Technological Organization, provide insight into the varying roles of technological design, production, use, maintenance, and discard within the broader context of changing cultural systems. It is through the implementation of this analytical framework that the nature of the technological decisions that were made are assessed, how these decisions changed through time, and how they facilitated the achievement of other cultural goals, such as subsistence pursuits, mobility strategies, and settlement organization.

The analysis of technological attributes is aimed at understanding various design considerations, as well as how those considerations reflect overarching design constraints. How tools were designed and manufactured is evaluated, including the influence that raw material choice and availability would have had on tool design. As discussed in Chapter 3, raw material availability, as a constraint on tool design, is an important factor for toolmakers to consider as they assess immediate and future tool needs and prepare to meet unanticipated technological requirements. The techniques involved in the production of various classes of artifacts are considered here. In addition, this chapter addresses such issues as the use of different core types in the production of blanks for various tool classes, the design and production of tools that could be reused or reworked, the manufacture of tools that were designed for limited uses, etc. The technological analyses are aimed at understanding how tools and technologies were designed and

produced in order to facilitate the achievement of other cultural goals. This chapter also presents a discussion of how changes through time in assemblage composition and production techniques reflect changing technological goals that are themselves a response to changes in broader behavioral and environmental patterns.

Certain attributes straddle the line between the “technologically” informative variables examined in this chapter and the “functionally” informative characteristics covered in the following chapter. These intermediate variables provide insight into the ways in which certain tool classes were treated throughout their use-lives (i.e., were they produced in order to be reworked/resharpened or for immediate use and abandonment?). These variables also demonstrate whether a tool had reached the end of its usable life (i.e., was exhausted) or whether it was discarded prior to exhaustion. These characteristics provide important insights into both the design process and the toolmakers’ evaluation of future technological needs, which itself lends an important perspective on the nature of activities while away from the site and the role that the occupation of Dust Cave played within the larger settlement-subsistence and technological cycles.

DATA COLLECTION OVERVIEW

With the exception of edge length, all measurements of tool dimensions (including various length, width, thickness measurements, scar size measurements, etc.) were taken using a set of Mitutoyo 6” digital sliding calipers. Because tool edges never are perfectly straight and can often be quite irregular, edge length was measured by following edge contours with a string that was then measured to the nearest 5 mm, to compensate for any manual inaccuracies in

measurement. All angle measurements, including interior platform angle and working edge angles, were measured using a contact goniometer. The data are presented in Appendix A.

Catalog Data

In addition to tool measurements and attributes, each tool class spreadsheet records several categories of non-technological data that serve to identify and locate each specimen, both within the site context and within the curation system. For each artifact, the following information was recorded:

- **BAG NUMBER:** all items recovered within a certain provenience were given a bag number for general identification.
- **ACCESSION NUMBER:** a unique identifier given to each find, which follows the format “1989.51.xxxxx.” In cases in which I have referred to specific artifacts (e.g., see tool descriptions, Chapter 4), I reference only the last 5 digits of the accession number.
- **BOX NUMBER:** allows each item in the curated collection to be located. Box numbers often represent groups of artifacts or sediment samples recovered during the same field season.

Provenience Data

For certain classes of artifacts, provenience data, including grid reference, depth, level, zone, and general zone are recorded. In some cases this information was used to interpret temporal-cultural affiliations (TCA) for artifacts that had not already had a TCA assigned. This was an important concern in my selection of specimens for microwear analysis from among the

intentionally and unintentionally modified flake categories, a process that is discussed in greater detail in the following chapter.

- GRID REFERENCE: this records the position of the artifact in 2-dimensions, with a “northing” and “easting” reference point on the site, relative to the established site datum. In other words, this data point represents the artifact’s horizontal location on the site.
- DEPTH: this records the third dimension of the artifact’s provenience, providing a vertical position for the artifact within the stratigraphy, relative to the established site datum. Most depths, apart from point proveniences that were recorded, were recorded as a range, corresponding to the excavation level within which the item was found.
- LEVEL: each arbitrary level that was excavated was given a level number, with smaller numbers representing upper stratigraphic layers, and larger numbers representing the lower levels.
- ZONE: geoarchaeological analyses of the stratigraphic deposits (Goldberg and Sherwood 1994; Sherwood 2001), in association with the presence of diagnostic artifacts, were used to establish a sequence of temporal-cultural zones that correspond to various periods of occupation:
 - Paleoindian: Zones U and T (Quad, Beaver Lake, Dalton)
 - Early Archaic: Zone R (Early Side Notched), Zone Q (mixed ESN and Kirk Stemmed), Zone P (Kirk Stemmed)
 - Middle Archaic: Zone N/P (Eva/Morrow Mountain?), Zones K, J, and E (Eva/Morrow Mountain), Zone D (Benton)

- Post-Abandonment: Zone A (included a few artifacts of later temporal cultural affiliations)
- GENERAL ZONE: I simplified the zone designation, ignoring the finer subdivisions and simply recording the zone letter, for the purposes of having large enough “populations” from which to choose samples for microwear analysis. Many of the sub-zones would not have contained sufficient modified flakes from which to draw samples, and so I considered the zone as a whole instead.

Type and Temporal Information

For several classes of artifacts, TYPE and SUB-TYPE classifications were recorded. Certain classes, such as scrapers and blade tools, encompassed a variety of types (e.g., Side Scrapers, End Scrapers) and sub-types (e.g., minimally flaked End Scrapers, dorsally flaked End Scrapers). The types and sub-types are recorded within the artifact class descriptions in Chapter 4.

The class of hafted bifaces includes categories for TYPE, CLUSTER and TEMPORAL-CULTURAL AFFILIATION (TCA). As I have already explained in Chapter 4, my recording of the hafted bifaces was primarily for the purpose of establishing temporal context. I did not take detailed measurements of this class of artifacts but did record the projectile point type, following Justice (1987) and the types defined by a variety of local researchers (e.g., Cambron and Hulse 1969; Chapman 1975; Coe 1964; DeJarnette et al. 1962; Kneberg and Lewis 1960). I divided these types into various clusters, based on Justice’s (1987) scheme, and provided a TCA for each artifact.

General Condition of the Artifact

Formality

This category assesses the amount of effort applied to producing a particular desired tool shape and maintaining that implement through cycles of use. I made this classification on the basis of a visual assessment of the amount of secondary flaking applied to the implement, as well as a consideration of certain attributes/variables, such as the presence or absence of a haft. Formality can also be assessed through examination of the degree of standardization among morphological and metric attributes, such as the dimensions of the proximal (haft) end. An assessment of tool formality provides insight into whether an implement or class of implements was designed for prolonged or immediate use and can shed light on the decision about whether or not to curate.

Material Type

An assessment of the raw material type used to manufacture a given implement was based on visual assessment of the artifact and its resemblance to samples in the comparative lithic collection housed at the University of Tennessee's Archaeological Research Laboratory (ARL). The majority of artifacts recovered from Dust Cave were manufactured from locally available Blue-Grey Fort Payne (BGFP) chert, which is available in both primary tabular deposits and secondary cobble deposits within a 1-2 km radius of the cave (Johnson and Meeks 1994). The ease of availability of this raw material likely was an important factor influencing certain technological decisions, including the types of tools that could be produced and the anticipation of future technological needs. BGFP is a high-quality, fine-grained, and easily worked stone that is available locally in large package sizes, thus eliminating many potential

limits on tool production. The ease of availability will have influenced toolmakers' concerns over future technological needs as well, shaping the emphasis on curated or immediate-use implements under various settlement/mobility conditions. Several non-local chert types were recognized in the collection as well, but with the exception of Burlington chert most occur in the bed load of the Tennessee River, near Dust Cave and likely do not constitute "exotic" raw materials.

Thermal Alteration

Some flintknappers heat-treat their raw materials prior to flaking, as thermal alteration generally is viewed as a means of increasing the flaking quality of certain types of stone (Kooyman 2000: 65). Through his knapping experiments, Crabtree (Crabtree and Butler 1964: 1) noted that he was able to remove substantially longer pressure flakes from materials that had been thermally treated. Other researchers have indicated that heat treatment reduces the tensile strength of certain lithic materials (Olausson 1983: 2), and serves to reduce the production of termination errors (Olausson 1983: 1; Price et al. 1982: 467; Purdy and Brooks 1971: 323-324). The reasons that thermal treatment increases flaking quality in some cherts continue to be debated among scholars. Some suggest that heating the material causes the SiO₂ (quartz) crystal structure to change and re-crystallize, allowing fractures to pass through these crystals, rather than being diverted around them. Opponents to this interpretation suggest that the low temperatures used in heat-treating would not have been sufficient to melt the silica. Domanski and Webb (1992: 610-611) demonstrated, however, that heat-treated materials exhibited smaller and more homogeneous sized crystals than did untreated materials, and that the weaker bonds around these crystals would have allowed fractures to travel between them more easily. Other

researchers suggest that heat-treating may drive out intercrystalline water, thereby increasing flakability (Kooyman 2000: 67). Regardless of the exact physical or chemical mechanisms, heat-treating certainly does appear, in many cases, to produce more easily worked raw materials.

In addition to potentially altering the internal characteristics, heat-treating also produces changes in the luster, color, and texture of cherts. Heat-treated cherts tend to take on a “greasy” luster and “soapy” feel, and the material frequently exhibits a reddish or pinkish color (Kooyman 2000: 65). Upon heating, Blue-Grey Fort Payne chert turns pinkish-red. It is possible that, because it is such a high quality and easily flaked chert in its unaltered form, the aesthetic value, rather than an increase in knapping quality, may have been a leading goal of heat-treating. Very few specimens in the assemblage were heated, which lends additional support to the notion that increasing the flakability of this stone may not have been a primary concern to toolmakers.

Condition

This variable records the condition of the tool when it entered the archaeological record: complete, relatively complete, or fragmentary. Complete tools retain their proximal, distal, lateral, dorsal, and ventral portions intact, with no damage apparent to any part of the tool. Relatively complete specimens are those that have only very minimal damage, with the remainder of the tool being intact. Fragmentary specimens include distal (tip), proximal (base/haft), or medial fragments. Tool condition provides insight into when tools were being discarded. Were tool users abandoning implements when their maximum utility had been reached, or were implements discarded only when they were broken? Were tools entering the archaeological record in exhausted form or after they had received only minimal use? I address these questions in conjunction with an assessment of tool “formality” in order to interpret the

condition in which implements from various tool classes were being discarded. We might expect that “curated” implements would have been discarded after more prolonged periods of use or only once they had been broken and that broken implements may have been reworked in order to extract any remaining utility from them. More “expedient” tools, on the other hand, may have been discarded in complete form after experiencing only minimal use.

Among the fragmentary specimens, I recorded the likely cause of the break. I considered whether tools were broken during manufacture, during use, or following discard. If broken during use, I also addressed what the nature of the break indicates about the activity in which the tool was being used when broken (see below).

Damage

This variable records where the damage occurred, or what part of the tool was recovered. I indicate whether the fragment is a proximal fragment (either proximal end of a flake blank, or proximal/haft end of a tool), medial fragment, lateral fragment (i.e., either the left or right half of the tool is missing), or distal fragment (either distal end of a flake blank or distal end of a tool). I also record the position of damage for those specimens classified as “relatively complete.”

Break Type

This category records the nature of the break and indicates its direction.

- Transverse: the break is oriented across the width of the tool or blank.
- Longitudinal: the break is oriented along the length of the tool or blank. Longitudinal fractures that originate at the tip of the tool (especially on hafted biface implements) and remove a lateral margin and/or part of the tool face are called “impact fractures”

(Dockall 1997: 325-326). These impact fractures are indicative of the tool tip hitting hard material (e.g., bone), which initiated a fracture as if the tip were struck with a percussor. Impact fractures are a fairly unambiguous and macroscopically visible indicator of tool use.

- Bending/Snap: bending fractures are those that occur away from the point of applied force. Bending fractures, which occur when “there is no opposing force directly under the point of impact” (Jennings 2011: 3645), can create transverse “snap” fractures that exhibit nearly 90° angles.
- Compression/Radial: compression fractures occur “if an opposing force is placed directly opposite the impact face” (Jennings 2011: 3645). Compression force can produce radial fractures, which are produced when the flake splits into more than three fragments that often exhibit lipping, cones of force, ring cracks, crushing, or *eraillure* scars where the force was applied (Deller and Ellis 2003; Jennings 2011: 3645). While radial breaks can represent a manufacturing error, this fracture type has also been produced purposefully. Jennings (2011) discusses the production of radial breaks in the manufacture of implements with steep, thick, and resistant engraving or scraping edges, while Deller and Ellis (2003) describe a case of apparent ritual radial breakage of bifaces at the Caradoc site. M. Miller (2006) notes that radial breaks often accompany perverse fractures, which are described below.
- Perverse: perverse fractures occur when a misdirected percussion blow initiates a conchoidal fracture at the edge of the piece being worked, and propagates a diagonal and twisting fracture through the material (M. Miller 2006).

Error

This attribute records the likely cause of the break, whether it occurred during manufacturing, use, or even post-discard. Certain break types are easier to assign to a causative category than are others. For example, the longitudinal type of impact fracture that is often seen on hafted bifaces is almost certainly the result of using that implement as a projectile tip.

Transverse or snap fractures, on the other hand, can occur during use (e.g., projectile impact, scraping pressure) *or* during manufacture (misdirected percussion force, for example; Dockall 1997: 326).

General Tool Dimensions

Length

Maximum length of the tool was recorded to the nearest 0.01 mm, using sliding calipers. On flake tools, the measurement was taken parallel to the axis of percussion, at the point of maximum length (following White 1963: 12). On bifacial implements, length was measured from the base of the tool to the maximum extent of the implement, along an axis extending perpendicular to the basal margin (“longitudinal axis” henceforth). Length may be used to infer original blank length, or it can contribute to an understanding of the point at which toolmakers decided to discard an implement. Specifically, when considered in conjunction with other variables discussed below, it can suggest whether tools were abandoned while utility still remained or when the specimen had become completely exhausted.

Width

Tool width was recorded at the point of maximum width of the implement, to the nearest 0.01 mm, using sliding calipers. The measurement was taken perpendicular to the axis of percussion on flake tools, or perpendicular to the longitudinal axis on bifacial implements, from one lateral margin to the other (White 1963: 12).

Thickness

Tool thickness was recorded at the longitudinal midpoint of the implement, to the nearest 0.01 mm, using sliding calipers. The measurement was taken between the dorsal and ventral surfaces, with care taken to avoid the thickened region of the bulb of percussion on flake tools (Wilmsen 1970: 14).

While each of these attributes is informative on its own, contributing to an understanding of overall blank size, width and thickness are often considered in association with other variables. For example, I investigate width-to-thickness ratios for bifaces. This ratio represents the degree of biface refinement, as bifaces tend to be thicker earlier in their reduction sequences. As efforts are made to thin the tool, thickness becomes reduced in comparison to width (Callahan 1979). Higher width-to-thickness ratios therefore represent tools that have progressed further through the reduction sequence. I use length-to-width ratios in my assessment of original blank and tool dimensions. One of the hallmarks of blades, for example, is that they are at least twice as long as they are wide. This ratio can also be used, in conjunction with other measures among certain tool classes (e.g., end scrapers) to assess how much utility remains in a tool.

Proximal Characteristics

Characteristics of the proximal ends of tools were recorded for complete and relatively complete specimens, and for proximal/haft fragments. When present, platform attributes of the original blank were recorded.

Proximal Width

The width of the proximal end of the tool, beyond the platform, was measured across the span of the lateral tool margins, 10 mm distally from the platform. This measurement was taken to the nearest 0.01 mm, using sliding calipers.

Proximal Thickness

The thickness of the proximal end of the tool, beyond the platform, was measured at the thickest point between the dorsal and ventral surfaces of the tool, 10 mm distally from the platform. This measurement was taken to the nearest 0.01 mm, using sliding calipers.

Proximal Thinning

I examined the proximal ends of tools, on both the dorsal and ventral surfaces, for evidence of intentional, post-detachment thinning (i.e., not related to platform reduction). The position of any such modification was recorded. Proximal thinning may indicate modification of the haft end of the tool to facilitate insertion into a standardized haft element and can include thinning of the bulb of percussion or modification of the dorsal and/or ventral surfaces of the proximal end.

Platform Length

This attribute was recorded to the nearest 0.01 mm, using sliding calipers. The measurement was taken across the maximum span between the left and right lateral margins of the specimen's platform (Wilmsen 1970: 14).

Platform Width

This attribute was recorded to the nearest 0.01 mm, using sliding calipers. The measurement was taken across the maximum span between the dorsal and ventral surfaces of the specimen's platform (Wilmsen 1970: 14).

Taken together, platform length and width give a sense of overall platform size, which can relate to the size of the original blank (e.g., Dibble 1997; Dibble and Pelcin 1995; Dibble and Whittaker 1981; Pelcin 1998; Shott et al. 2000). Examination of platform sizes among tools in a particular class can also suggest the relative importance placed on core standardization during production (i.e., was the core produced in such a way as to produce flakes in a consistent manner, or were flakes removed haphazardly?).

Exterior Platform Angle

In measuring the angle of the platform, the measurement must either be taken between the platform surface and the dorsal face of the flake or between the platform surface and the ventral face of the flake. The former is called the "exterior platform angle," and the latter is called the "interior platform angle." Lithic analysts have debated the utility of both of these measurements for providing information about original blank characteristics. While each measurement can be informative about flake or blank characteristics, each reflects a different

category of attributes. Interior platform angle tends to be associated with those characteristics formed through flake detachment, while exterior platform angle indicates “characteristics that were present prior to detachment of the flake” (Cochrane 2003: 13). Exterior platform angle (EPA), therefore, is more informative regarding the nature of the core from which the flake was derived as the EPA was established prior to removal of the flake from the objective piece.

EPA is measured between the surface of the platform and the face of the core. This angle can be created or altered by the application of various preparation types (e.g., reduction, grinding). Research has demonstrated that EPA is largely responsible for determining whether or not a flake will be detached successfully. Other production factors, such as load application, which itself is influenced by weight or hardness of the indenter, production technique (pressure or percussion), and velocity and accuracy of the blow, also contribute to successful flake removal (Cochrane 2003: 14). In general, higher exterior platform angles require greater load application in order to detach a flake, and are often associated with hard hammer percussion. Lower platform angles, on the other hand, may indicate flake detachment with a soft percussor, which disperses the percussive force. EPA, therefore, is a useful variable for assessing the nature of the original core, as well as the production techniques and hammer types employed. I measured exterior platform angle, to the nearest degree, using a contact goniometer.

Platform Preparation

I observed the tool platforms in order to identify evidence for the preconditioning of the core for flake removal (Wilmsen 1970: 14). Platforms can be prepared, or can be left untouched. Frison and Bradley (1980: 27) indicate that unprepared surfaces show that toolmakers found the platforms to be “sufficient without any further modification to produce the desired flake.” Lack

of platform preparation may also signify that the toolmaker was not concerned with producing flakes that exhibited particular characteristics and, instead, was content with selecting appropriate blanks from among the variety of flakes that were produced. These platforms can retain cortical surfaces, they can be flat, or they can retain facets from prior flake removals on biface cores. Prepared platforms, on the other hand, demonstrate that the original platform surface had to be modified in order to allow the successful removal of a flake with a desired size or shape (Frison and Bradley 1980).

I observed several platform characteristics and platform preparation types in the Dust Cave assemblage, each of which contributes to my interpretation of the core type from which flakes were derived.

- Cortical: A cortical platform “is simply composed of the unmodified cortical surface of the objective piece” (Andrefsky 1998: 93). The presence of cortex on the striking platform indicates a lack of platform preparation, as well as suggesting that it was removed early in the reduction of the objective piece.
- Flat: Flat platforms are smooth and single-faceted platforms that indicate removal from non-bifacial, and often unidirectional, cores. These striking platforms generally exhibit exterior platform angles between 75° and 90° (Andrefsky 1998: 94-95).
- Facetted: Facetted platforms retain scars from the removal of previous flakes from the platform surface and are common on biface-derived flakes whose platforms represent a portion of the flaked biface edge. Various researchers have demonstrated that platform facet counts are correlated with biface reduction stage

(e.g., Carr and Bradbury 1995; Magne 1985). This category relates to Andrefsky's (1998: 95) "complex" platform type.

- Ground: The platform surface can be ground where the dorsal face meets the platform in order to reduce an edge angle that is too shallow and weak to allow successful removal of a flake (Ellis 1984). Andrefsky (1998: 96) notes that platform abrasion may also be applied in order to "eliminate the uncertainty of the direction of force created by multiple flake scars and/or step fractures on the striking platform." This form of preparation likely reflects greater investment in core preparation in order to promote increased predictability in flake removal. Platform grinding is often observed on flakes derived from biface cores, which tend to have thinner edge margins (striking platforms).
- Reduced: A series of small, overlapping, step-terminated flakes, originating from the striking platform, are removed from the dorsal surface of the platform end in order to reduce platform thickness or remove platform overhangs (Clarkson and O'Connor 2005; Frison and Bradley 1980; Marwick 2008: 1193).

Very often, these preparation types occur in combination, reflecting various preparation strategies. For example, flakes produced through biface reduction will often exhibit the platform faceting indicative of removal from bifacial cores but will also reveal evidence for platform abrasion in order to thicken the edge for flake removal.

Lateral Characteristics

Lateral Expansion

The degree of expansion of the lateral margins of certain tool classes was recorded as an increment of 5° (e.g., 20°-25°). Measurements were taken by placing the tool, ventral surface down, on a polar coordinate grid, with the left lateral margin aligned along the 0° axis. The position of the other lateral margin on the grid signifies the degree of lateral divergence. This attribute is important to consider for certain tool classes that appear to have been more standardized in their proximal measurements, and may be one indicator of the use (and re-use) of standardized hafts.

Lateral Modification

Certain tool attributes, such as morphology of the working edge, angle of the working edge, tool width, and tool thickness, are altered through the application of secondary flaking along the lateral margins of flake blanks. Flakes are removed from the margins of the tool and can either be limited to the blank margins (marginal modification), or can extend onto the surface of the tool (dorsal modification). In extreme cases, secondary flaking can also be applied that stretches well past the midpoint of the tool, all the way to the opposing margin.

Certain tool classes, such as the complete dorsally flaked end scrapers, exhibit extensive secondary modification. The dorsal flake scars seen on these implements were not produced during initial core reduction but instead were applied after detachment of the blank from the objective piece. These scars originated along the lateral margins of the tool and, therefore, are recorded in the category of “lateral modification” rather than as a characteristic of the dorsal surface.

The degree of lateral modification observed on tools is an indicator of the amount of effort that toolmakers invested in modifying the original blank form. This attribute provides insight into two behavioral concerns. First, it is an indicator of the overall degree of effort that the toolmaker was willing to expend in modifying the tool, which itself suggests how that tool/tool class was conceived (i.e., was it being produced for immediate use, or for future anticipated needs?). Second, lateral flaking reflects the amount of post-detachment modification that was necessary before the blank was suitable for tool production. This can shed light on the degree of investment in core production, and whether cores were being prepared so as to allow the detachment of flakes with predictable sizes or shapes, or whether toolmakers were producing less prepared objective pieces and simply selecting suitable blanks from among the variable flakes that were detached.

Working Edge Characteristics

Here I discuss a series of attributes that describe the nature of the portion of the tool intended for use (i.e., the portion that was in contact with the worked material). I begin with general variables that indicate where on the blank this working edge was located and whether or not it was altered intentionally. Please note that my use of the term “working edge” here should not be confused with my discussion of working edge vs. bit characteristics, below. The former refers to what Knudson (1983) called “employable units” (i.e. portions of the blank margin that were utilized), while the latter differentiates between the working portion of the tool on different tool classes.

Attributes of the “working edge” are considered for items that exhibit either intentional secondary modification or unintentional use damage along one of the blank margins. Tools such

as side scrapers, bifaces, and knives possess “working edges” that are contiguous with tool or blank margins, as opposed to being distinct or somehow separate from the overall outline morphology. Working edges tend to be located along lateral blank or tool margins.

Position of Working Edge/Secondary Modification

For most tool classes, I recorded where on the blank secondary flaking was applied in order to modify a working edge or to modify the outline morphology. Secondary modification was recorded as being present on any combination of the proximal, distal, left lateral, or right lateral margins. The position of this modification suggests what portion of the tool was designed to contact the worked material (Andrefsky 1998: 168) and provides insight into tool function. Certain tool types may possess more than one working edge, with each designed for a different function. In addressing questions of the role of technologies within broader cultural systems, this becomes an important consideration, as the design of multifunctional tools may relate to concerns over anticipated or unanticipated technological needs in mobile systems, or the need for portability (see discussion of design considerations and design constraints in Chapter 3).

Continuity of Working Edge

This attribute indicates whether the flake scars produced through secondary flaking applied to the working edge were continuously or discontinuously distributed (Andrefsky 1998: 172). A consideration of the continuity of secondary flaking, in association with the size of flakes, may indicate whether this modification was applied intentionally (continuous and larger) or produced spontaneously during episodes of use (discontinuous or continuous and smaller).

Scar Size

Length of the secondary flake scars was measured to the nearest 0.1 mm, using sliding calipers. As with continuity of the secondary flake scars, scar size is an indicator of whether flake scars along the working edge were applied intentionally, in order to modify the shape or angle of the edge, or whether they were incurred incidentally as damage from use. Generally, scars greater than 2-3 mm in size are considered to be indicative of intentional flaking, while scars less than 2-3 mm are considered to represent use damage (Kooyman 2000: 154). An assessment of scar size proves useful in interpreting whether tools were produced for extended longevity or immediate use.

“Bit characteristics” are considered for tools that exhibit intentional secondary flaking or unintentional use damage along a portion of the tool or blank that is somehow separate or distinct from the overall blank outline (i.e., where there is a definite break in the outline of the tool margin). Tools such as end scrapers or perforating implements (i.e., drills, perforators, gravers) tend to have bits that, while connected to the rest of the tool body, are somehow distinct from it. End scrapers, for example, exhibit intentional, steep secondary flaking along the distal margin, which often is modified into a convex (projecting) bit margin. While the lateral and proximal margins can be altered for prehension, secondary flaking, when present, often produces more acute margins and is contiguous with the natural blank outline. Similarly, perforating tools such as gravers or drills have bits that project from the contour of the tool body.

Bit Length

This attribute applies to drills, perforators, and gravers. The length of the projecting bit end is measured along the longitudinal axis, from the juncture between the bit and the body of

the tool, to the end of the bit projection. This measurement is taken to the nearest 0.01 mm, using sliding calipers.

Measurements of bit length were used, in association with bit width, to discriminate between “drills” and “gravers/perforators” (see below).

Bit Width

This attribute applies to drills, perforators, gravers, and end scrapers. On perforating implements, I measured the width of the bit at the midpoint of the projection. For end scrapers, I measured bit width across the lateral margins, at the juncture between bit and tool body. These measurements were taken to the nearest 0.01 mm, using sliding calipers.

As mentioned in the preceding definition, bit length and bit width were used to partition the assemblage of perforating tools into the “drill” and “graver/perforator” classes. Drills had a mean bit length to bit width ratio of 3.5, while gravers/perforators had a mean bit length to bit width ratio of 1.8. Drills therefore possessed bits that were nearly twice as long as they were wide, compared to the bits on gravers and perforators.

Bit Depth

This attribute was recorded only for end scrapers. I measured bit depth, following Lancashire (2001: 87), at the maximum “extent of the bit from a straight line joining its left and right bit corners.” The measurement was taken to the nearest 0.01 mm, using sliding calipers.

Bit Thickness

This attribute was recorded only for end scrapers. Bit thickness was measured vertically at the point between the ventral surface of the tool, and the juncture between the dorsal surface and the termination of the bit modification flake scars. This measurement was taken to the nearest 0.01 mm, using sliding calipers.

Bit Angle

Bit angle measurements were taken for end scrapers only. Using a contact goniometer, I measured bit angle at three separate points and recorded a range of angles, to the nearest 5° (e.g. 65°-70°). This measurement was taken between the ventral surface of the tool and the incline of the bit modification scars. Bit angle is an informative characteristic regarding the nature of the worked material, and the working activity (e.g., cutting, scraping, whittling, boring, etc.) (Andrefsky 1998: 169). I discuss this further in my discussion of “Working Edge Angle,” below.

Bit characteristics, when considered in association with one another, can provide insight into implement function. For example, as discussed above, an assessment of bit length and bit width allowed me to distinguish between drills and gravers/perforators, and may be suggestive of function (i.e., how far into the worked material the bit was designed to penetrate, which may be correlated with thickness of the worked material). A consideration of the ratio of bit width to thickness can also be useful in interpreting function, as it may suggest the degree of force the bit was designed to withstand.

Examination of the bit can also provide a means to understand tool use-life. Bit characteristics can change throughout a tool’s use-life in response to successive episodes of use and resharpening. End scraper bits, for example, which begin their use-lives as moderately steep

and convex working margins, become steeper and less convex through successive episodes of resharpening (Ellis and Deller 2000; McMillan 2003; Morrow 1997). A flat and very steep bit therefore indicates that a tool has been utilized for longer. When considered in association with other tool attributes, such as tool length, bit characteristics can reveal important insights about the decision to discard implements.

Attributes of the “working edge” were considered for tools whose *lateral* margins were utilized, including bifaces, various scraper types (side, ovoid, humpback), some general uniface specimens, intentionally and unintentionally modified blade tools, and both intentionally and unintentionally modified flakes. While the “bit” was often identified by a break in the outline morphology that produced a working portion that was distinct from the rest of the tool body, the “working edge” is a portion of the tool that exhibits intentional secondary modification or that exhibits edge damage as a result of use, but that is contiguous with the overall outline morphology.

Working Edge Morphology

Working edge morphology was assessed visually and includes straight, concave, convex, recurvate, undulating, and serrated variants. Recurvate margins exhibit both a convex and concave portion along the same margin. Undulating margins are those that exhibit multiple convex and concave portions that are coarser and more rounded than what I consider to be “serration.” Serrated margins exhibit a series of smaller, pointed “teeth.” The morphology of the working edge provides clues to tool function, as different edge shapes would have been useful for different task requirements.

Working Edge Length

Length of the working edge was measured using a string to follow the edge contours. I then measured the length of the string segment to the nearest 5 mm in order to compensate for my inability to measure accurately, by hand, each small undulation. If more than one margin was utilized, I measured and recorded each separately. The length of the working edge may suggest tool function, as it can be correlated with intended depth of tool penetration (e.g., knife edges vs. drill bits) or anticipated degree of contact with the worked material (e.g., a spokeshave, whose concave working edge will only contact a narrow segment of a rounded wooden shaft; a knife that is designed to make long strokes through pieces of meat).

Working Edge Angle

Angle of the utilized portion of the tool was measured using a contact goniometer. Multiple measurements were taken along the length of the working edge and were recorded as a range of angle measurements (e.g., 65°-75°). If more than one margin was utilized, I measured and recorded each separately. Consideration of the working edge angle provides important insight into tool function. Different edge angles are more or less effective for completing a variety of tasks and, in some cases, can even be detrimental to the accomplishment of certain activities. Programs of ethnoarchaeological research among extant stone tool-using societies (e.g., Gould et al. 1971; Hayden 1979) and functional studies of archaeological materials (e.g., Semenov 1964; Wilmsen 1968) have provided important insight into tool function. In their work among the Western Desert Australian Aborigines, Gould et al. (1971) noted that toolmakers based their own emic tool type classifications more on the nature of the working edge, especially the edge angle, than on any other elements of tool form. While this is only one case that suggests

the importance of working edge angle, it has become widely accepted that edge angle is of great functional significance.

Based on both the ethnographic and archaeological observations, most lithic analysts agree that more acute edge angles (generally $<60^\circ$) are most effective for both cutting and sawing tasks (Gould et al. 1971; Hayden 1979; Wilmsen 1968). Steeper or more obtuse edge angles (i.e., $>60^\circ$) are better suited for carrying out tasks such as hide scraping, chopping, or adzing (Gould et al. 1971; Hayden 1979; Wilmsen 1968). Thinner, more acute working edges would not be suitable for hide scraping because they would cut into the hide rather than gliding across its surface, nor would they be able to withstand the greater amounts of force applied during heavy chopping or woodworking (e.g., adzing).

Scar Counts

This attribute was recorded for bifaces only. I considered the numbers of secondary flake scars that intersect the left and right lateral margins of both the obverse and reverse faces of the tool. As described in Chapter 4, I considered scar counts in association with the length of the working edge, in order to assess the position of the implement within the reduction continuum. As suggested by Miller and Smallwood (2012), higher scar counts per unit of edge length indicate specimens that have proceeded further through the reduction sequence.

Dorsal Characteristics

The dorsal surface of a flake represents a small portion of the outer face of the core, prior to detachment of that flake. If flake blanks are left relatively unmodified, they can retain characteristics that reveal the nature of the original parent piece.

Dorsal Scar Number

Dorsal scars are those scars that remain on the dorsal surface of a flake blank as a result of prior flake removals from the core, rather than as a result of post-detachment secondary modification or retouch, or platform reduction. This attribute provides insight into the type of core from which the blank was removed, and the stage of core reduction.

Dorsal Scar Nature

The nature of dorsal scars considers how the scars relate to one another. I record whether scars are (parallel) unidirectional, (parallel) bidirectional, convergent, centripetal, or multidirectional/haphazard.

- Unidirectional: originates from only one end/margin of the flake blank.
- Bidirectional: originate from both ends/margins of the flake blank.
- Convergent: originate from one end/margin of the flake blank and converge toward the opposite end/margin.
- Centripetal: scars originate from all flake margins and converge on the center of the blank. This pattern is characteristic of biface-derived flakes.
- Multidirectional/haphazard: randomly oriented flake scars.

Dorsal Scar Origin

This variable records the portion of the flake blank from which dorsal scars originated: proximal, distal, proximal/distal, lateral, or all. Dorsal scar origin indicates the direction of prior flake removals from the objective piece and is assessed based on observation of the orientation

of conchoidal fractures (concentric cracking “ripples” that radiate outward from the point of percussion) in the negative flake scars.

Dorsal Cortex

This variable records presence or absence of cortex or weathered patches on the dorsal surface of the tool. The presence of dorsal cortex can indicate a) the nature of the raw material source, and b) the stage of core reduction.

Cortical surfaces on raw materials are produced through either chemical or mechanical weathering of a piece of raw material (Andrefsky 1998: 101). Chemical weathering occurs when the composition of the stone is altered through exposure to elements such as moisture or heat. This process often produces color changes in the outer surface of the raw material. Mechanical weathering, on the other hand, occurs when the texture of the raw material is altered through contact with abrasive substances. Mechanical weathering is responsible for much of the cortex development recorded on flakes and flake tools from Dust Cave. Pieces of Fort Payne chert, which outcrops in the limestone bluffs in the vicinity of Dust Cave, eroded into the river valley below, and their surfaces were subsequently altered as the nodules were rolled in the river. This “cobble cortex” is characterized by a rough, “orange-peel” texture and, in the case of the Fort Payne examples, often exhibits a lustrous brown patina.

In addition to providing insight into the nature of the raw material sources exploited, cortex can also be used to interpret the reduction stage of tools. Andrefsky (1998: 101-102) explains “This is based on the assumption that the weathered exterior of lithic raw materials – the cortex – will be the first area removed in either tool production or core reduction.” As successive flakes are removed, progressively less of this cortex will remain on their dorsal surfaces. Flakes

with very little or no cortex therefore are assumed to represent later stages in the reduction sequence than are specimens that retain larger amounts of dorsal cortex.

Position of Dorsal Cortex

If dorsal cortex was noted, I also recorded its location on the specimen: proximal, distal, left or right lateral, complete, platform, etc.

Ventral Characteristics

I recorded only one attribute of the ventral surface of flake tools: ventral curvature. Elsewhere I did consider the presence of proximal thinning, which can be applied to the ventral surface to thin the bulb of percussion, but because proximal thinning can also encompass alterations to the dorsal surface it is not considered here.

Ventral Curvature

Using a variation of the rim diameter charts used by ceramicists, I recorded the degree of curvature of the ventral surface. The curvature of the flake was measured on a grid with concentric circles placed at 1 cm intervals. The inner circle (labeled “1”) possessed a more curved arc, while the outermost circle (labeled “16”) possessed a flatter arc (i.e., less curvature). The flake tool was positioned on its side, with its ventral surface held against the arcs of the circles, and the curve of its ventral surface was matched to the appropriate circle.

This attribute contributes to an assessment of the nature of the original core form, as well as to the reduction stage for certain core types. Ventral curvature tends to be more pronounced for flakes derived from biface cores and flatter for flakes produced from blocky or blade cores.

Among biface-derived flakes, though, ventral curvature has been shown to decrease throughout the reduction sequence (Andrefsky 1986; Gilreath 1984).

Interpreting Core Type

Allocation of time and energy for tool production is an essential technological behavior to consider because it reveals an important facet of the technological organization process as it relates to concerns over time and energy available for other tasks. Changes in the way that time and energy are allocated to tool production may reflect changing technological concerns or shifts in broader adaptive challenges.

The decision about how much time and effort to invest in tool production occurs early in the manufacturing sequence, with the selection of core technology (i.e., the type of core to utilize in the production of tools or blanks). Certain core types, such as biface cores or blade cores, produce predictable flake types and require greater investment in their preparation, while other cores involve more haphazard removal of flakes and little preparation for blank removal.

Blank/Core Type

Based on simultaneous assessment of many of the attributes described in the above sections, I interpret the types of cores utilized by toolmakers in the production of blanks and tools at Dust Cave. I consider a variety of attributes in combination, including platform characteristics, ventral curvature, and dorsal scar patterning. These attributes allowed me to associate blanks with a type of core from which they were struck. If original blank characteristics were missing or otherwise ambiguous, the tool was assigned to an “unknown” category. I identified several core types in the assemblage: blocky, multidirectional/haphazard/amorphous,

biface, blade, bipolar, and split cobble. Below, I define my own use of these terms, and consider how my definitions relate to those used by other researchers. I outline the resulting flake attributes that are characteristic of removal from each of these core types.

Callahan has defined *Blocky Cores* as “squarish, cylindrical, or polyhedral core[s]” (Callahan 1979: 41) with either prepared or unprepared striking platforms. He notes that his category includes Crabtree’s conical, cylindrical, rectangular, tabular, and polyhedral types (Callahan 1979: 41). For my own purposes, I distinguish the unprepared and often more angular blocky forms from the highly prepared “blade core” forms, as the latter are highly specialized cores designed to produce a very specific flake type (see discussion, below). Blocky cores are similar to blade cores, but lack prepared platforms and, as Callahan describes, “do not have the overhang from the prior blade removed” (1979: 53). Flakes derived from these cores often exhibit flat, relatively obtuse striking platform angles, and variable flake morphology (Daniel 1998; Lothrop 1988: 108). It is possible that these cores represent early stages of the production of true blade cores.

Blade Cores, a unidirectional type of blocky core, are characterized by flake removals in the same direction from a single, prepared striking platform (Andrefsky 1998: 15). True blades are removed from these cores by directing the applied force to “follow one or more ridges or convexities and are typically long and parallel-sided” (Callahan 1979: 53; see also Crabtree 1972: 42). These ridges and convexities, which represent the parallel, unidirectional dorsal flake scars that are left after prior flake removals, contribute to the production of thick, triangular or trapezoidal cross-sections of subsequently removed blades. Blades exhibit flat striking platforms, with evidence for reduction/preparation, and obtuse striking angles that approach 90° (Daniel

1998: 139). Faceting is sometimes visible on platforms as a relic of later-stage platform rejuvenation attempts.

In contrast to the blocky and blade cores described above, *multidirectional cores* possess multiple striking platforms from which flakes are removed in various directions. Andrefsky notes “Multidirectional cores must be turned or rotated to remove flakes from the different striking platforms and, as such, are sometimes called rotated cores” (1998: 15). Some of these exhibit a discoidal shape (disc cores), while others possess two distinct faces that meet at a single edge around the circumference of the piece (biface cores). I consider biface cores, which are multidirectional, separately from my category of less formal multidirectional cores.

Biface cores exhibit the same basic defining characteristics as bifacial tools: they are flaked on two opposing faces that meet at a single, continuous edge that circumscribes the piece. I have already discussed the distinction between bifaces (utilized as tools) and biface cores (utilized for producing flakes for tool manufacture) in Chapter 4. It is the latter category that I describe here. The edges of biface cores were often ground and beveled in order to thicken the edge for successful flake removal without edge collapse (Callahan 1979: 117; Lothrop 1988: 108). Striking platforms on biface-derived flakes tend to exhibit angles that hover around 70° (Callahan 1979: 117; Lothrop 1988: 108). These platforms also frequently exhibit “lipping,” or an overhang on the ventral surface (Dibble 1988: 139-140). While the dorsal surface of the flake represents a segment of one face of the biface core, the overhanging lip on the ventral surface of the platform end represents a small remnant of the opposing face of the original objective piece. These lipped platforms are often faceted, with facets being remnants of flake scars that intersected the edge of the biface and tend to exhibit abrasion, which is applied to the biface edges in order to thicken edges and prevent collapse during flake removal (Callahan 1979: 30).

Flakes derived from biface cores exhibit complex dorsal scar patterns, a relic of the multiple and convergent prior flake removals from the biface surface. Flakes are struck from the biface edges and converge on the center of the piece (Callahan 1979: 63). In longitudinal section, biface-derived flakes can exhibit varying degrees of ventral curvature, which reflects the removal of flakes from a biconvex core form. Bifaces are especially thin at the edges, and thicker at the midpoint. If flake removals travel past the midpoint of the specimen, they may exhibit ventral curvature as they travel past the apex of the median and toward the opposing thinned edge.

Another particularly specialized multidirectional core form is the *Bipolar Core*. Bipolar objective pieces have flakes removed from both the proximal and distal ends simultaneously. These flakes are removed by placing the objective piece on a hard surface, or anvil, and striking the top surface, causing the fracture to propagate from both ends simultaneously. The flakes that are produced are crushed at both the proximal and distal ends, and exhibit two points of percussion. Indicators of flake removal direction (e.g., compression rings) show bidirectional flake removal (Andrefsky 1998: 149).

While these abovementioned core types fall within the category of “multidirectional flake removal,” I use the term *multidirectional core* to refer to objective pieces that exhibit no particular patterning in flaking. These may also be labeled “haphazard” or “amorphous” cores. Flakes are removed from multiple opportunistic platforms, in various and unpatterned directions, producing haphazard dorsal scarring. These flakes also exhibit variable platform preparation types and morphological characteristics.

ASSESSING VARIABILITY AND UNDERSTANDING TECHNOLOGICAL CHANGE

The major goal of this dissertation is to address the nature of technological organization strategies through time at Dust Cave and how these strategies relate to changes in environmental conditions, resource structure and availability, and foraging patterns. Central to the development of an understanding of technological changes through time is the assessment and interpretation of variability within the assemblage, including differences in assemblage composition, in technological patterns, and in functional patterns. Variability may enter the assemblage at several points in the technological sequence, from initial raw material selection, through core production and reduction, tool manufacture, tool use, and maintenance.

Much of this variability is a response to different technological needs that are met in the context of broader cultural strategies (e.g., degree of settlement mobility, diet breadth, etc.). Strategies of settlement, subsistence, and social organization can determine the types of tools that are required at any given site, the length of time for which tools are used, and in what manners they will be used (i.e., curated and resharpened or utilized expediently). It is, therefore, useful to consider variation in assemblage composition, with specific reference to what tools were used and in what quantities at various points in the occupational sequence.

Binford (1977, 1979, 1980) considered the relationships among assemblage composition, prehistoric behavior, and site function. Because different artifacts are associated with different activities, and different activities are pursued within different settlement-subsistence organizational strategies, assessing the range of artifact types recovered at any given site can offer clues to site function and to broader organizational patterns. For example, in Binford's (1980) conception of collector groups, populations inhabit a residential site for extended periods of time and send out task groups to procure resources that are then returned to the main camp for

use by the group. In this type of settlement system archaeologists should expect to see larger, multi-purpose residential bases that were occupied for extended periods of time, as well as smaller, single-purpose activity loci including hunting camps, toolstone extraction locales, etc. These different site types should be recognizable on the basis of differences in the size, composition, and diversity of their artifact inventories. For example, at residential sites where people engage in a wide range of everyday activities such as processing, preparation and consumption of foodstuffs, manufacture and repair of implements (including stone tools and other items of technology), preparation of hides, etc., we would expect to see a wide array of artifact classes representing this broad spectrum of activities carried out at the site. In contrast, a simple hunting station, where hunters dispatched their prey and perhaps performed some initial processing, should be characterized by a much narrower range of artifact types associated with hunting and butchery. By considering changes in assemblage composition at Dust Cave, through examination of shifts in artifact class representation and frequencies, it is possible to interpret the role that this site played in the broad organizational structure of its inhabitants. If we understand how the site functioned, and what activities were carried out there, then it becomes possible to interpret how other behavioral needs were being met through the design of these variable technologies and what role the site played, at any given time, within the cultural system.

Beyond simply considering variability in the presence/absence of artifact types over time, it is also useful, in an assessment of technological change, to consider variability in the ways that tools were designed, produced, and used, both within and between tool classes and time periods. Variability between artifact classes over time provides insight into how technologies change, as well as how those changes are related to broader cultural patterns. The degree of variability or standardization that exists within particular artifact classes from individual time periods provides

insight into technological choices such as the emphasis on tool formality, or the decision to emphasize curation or expediency in tool production.

Assessment of standardization can be undertaken by considering certain statistical measures of variability such as the Coefficient of Variation (CV), a measure of the distribution of data points around the mean. The CV is calculated as a ratio of the standard deviation to the mean and is often expressed as a percentage. CVs therefore allow comparison of the extent of variation between samples, while taking into account the effects of variation in mean values (Shennan 1997: 44).

In a 2001 article, Eerkens and Bettinger tested the applicability of coefficients of variation to studies of archaeological samples. Their results suggested that variability can be quantified and that CVs are useful for assessing that variability. Differences in the degree of variation within or between samples are the product of the amount of deviation that toolmakers will tolerate from their preconceived “templates” (e.g., size, shape, or tool production methods). If the level of tolerance is higher, or if no mental template existed (e.g., as in the case of simple intentionally or unintentionally modified flake tools), then technological assemblages will exhibit greater variability. Conversely, if toolmakers are less tolerant of such deviations, then more standardized assemblages will be produced. Standardization then represents the degree of emphasis on producing items that are the same as one another and is “related to the life cycle of the artifact type or class in question, reflecting such things as production costs, consumer preferences, replication and learning behaviors, number of producers, concern with quality, producer skill, and access to resources” (Eerkens and Bettinger 2001: 493-494).

Eerkens and Bettinger (2001) discuss how little variation humans are capable of producing without the assistance of measuring devices and what amount of variation can be

expected when producers are not concerned with standardizing products. Error is inevitable in the manufacturing process, as minor variations are introduced any time a human toolmaker attempts to replicate an item. The major source of this error is scalar, arising as a result of difficulties in estimating the size of objects and then applying this already skewed mental template to the production of subsequent items (Eerkens and Bettinger 2001: 494). Scalar error is related to the size of the object, with larger items producing greater errors in estimation.

Human perceptive abilities and motor skills place limits on the degrees of variation we can expect in assemblages. Eerkens and Bettinger (2001) refer to psychophysical experiments conducted by E.H. Weber in the mid-1800s that were designed to test the abilities of humans to differentiate between objects of different masses. Weber's results demonstrated that differences in weights could be detected only at levels of 2% or greater. Heavier objects, therefore, must vary more in mass than lighter objects in order for the difference to be perceived. Similarly, inequalities in linear dimensions cannot be perceived unless the difference is greater than 3%.

Based on these observations, Eerkens and Bettinger (2001) propose upper and lower limits for coefficients of variation in samples of artifacts. In normal distributions with values between 0 and X , the coefficient of variation is always 57.7% ($1/\sqrt{3}$). Eerkens and Bettinger explain this phenomenon as follows: "the mean of a uniform distribution on $[0,X]$ is $X/2$ and the standard deviation is $X/\sqrt{12}$. Thus, the CV is $2/\sqrt{12}$, or $1/\sqrt{3}$, or 57.7%" (2001: 504). Any coefficients of variation above this value indicate intentional production of differences. At the other end of the scale, the Weber fraction dictates that the minimum amount of variation discernible by humans produces CV s, in non-randomly produced samples, of 1.7%. Values below this number indicate the use of measuring devices or automated production. For the purposes of this dissertation, CV s below 10% indicate extremely high levels of visual

standardization. Values between approximately 10% and 20% are considered to be relatively standardized. Moderate levels of standardization are those that lie in the range of 20% to 30%, and any values approaching or surpassing 40% are considered to be unstandardized.

To assess variability in different samples, we need to be able to compare coefficients of variation. Homogeneity of Variance (HOV) tests exist for assessing relative degrees of variation, but these methods are useful only if sample sizes are approximately equal, which is a situation rarely encountered when one analyzes archaeological samples. Eerkens and Bettinger (2001: 499) present a formula for calculating the D'AD statistic, which allows evaluation of the comparability of CVs between samples, taking into account differences in sample sizes:

$$D'AD = \frac{\sum_{j=1}^k \left(\frac{s_j}{\bar{x}_j} - D \right)^2}{D^2 (0.5 + D^2)}, \text{ where } D = \frac{\left(\sum_{j=1}^k m_j \frac{s_j}{\bar{x}_j} \right)}{\sum_{j=1}^k m_j}$$

Following Eerkens and Bettinger (2001: 499) “ k is the number of samples, j is an index referring to the sample number, n is the sample size of the j th population, $m_j = (n_j - 1)$, s_j is the standard deviation of the j th population, and \bar{x}_j is the mean of the j th population.” The D'AD test for differences in CVs provides a measure of how far each sample's CV lies from an overall population CV and is “distributed as a χ^2 random variable with $k-1$ degrees of freedom” (Eerkens and Bettinger 2001: 499).

Other sources of variation that are important to consider in archaeological assemblages include some that are not related to manufacturing choices or technical skill. The nature of lithic raw materials can introduce variability into an assemblage, as the result of either natural

variation within the raw material types or the presence of multiple material types within a given assemblage. At Dust Cave raw material variation is less of a concern, as most of the assemblage was manufactured from locally available, high quality, fine-grained Fort Payne chert. Raw material variability and differences in knapping quality therefore are less significant sources of variation.

Assemblage variability is also introduced through the process of resharpening used and dulled implements. Kuhn (1990: 583) argues “The resharpening of tools is an economical tactic for producing sharp, usable edges while minimizing the cost of transporting multiple tools or bulky raw material.” It therefore has important implications for our understanding of curation, raw material economy, site use, artifact reuse, and the meaning of morphological differences within and between artifact classes. Differing degrees of artifact reduction indicate differences in the amount of utility being extracted from individual specimens and from whole classes of artifacts. These differences are important to study as they contribute to an understanding of manufacturing choices that are related to broader cultural concerns. Changes in these patterns then provide insight into patterns of settlement, subsistence, technological, and social change. These trends are of particular importance in this dissertation, as shifts are evident in the proportions of particular tool classes that suggest that the production of certain curated implements, with the exception of hafted bifaces, appears to have diminished in importance through time. Over time, formal, hafted, unifacial implements essentially disappear from the assemblage, and intentionally and unintentionally modified flake tools became more prevalent. I am interested in considering the role that these unifacial and simple flake implements played in the technology and what position they occupied within the system of technological organization.

To assess how much resharpening a tool underwent we need a way to calculate the amount of material that has been removed, or at least a proxy measure for use and reuse. Various methods have been devised, through the implementation of programs of controlled experimentation, for evaluating original blank size and the subsequent degree of reduction (e.g., Dibble and Whittaker 1981; Speth 1974, 1981). Dibble and Whittaker (1981) devised an experiment that was designed to allow the prediction of flake size and flake features produced under a variety of controlling influences (production factors), such as the angle of the detachment blow and the force of impact. In their experiments, Dibble and Whittaker removed flakes from glass cores by dropping ball bearings, held and released by an electromagnet, onto the platform of the core. Results of their experiments suggested that the force of impact, the thickness of the platform, and the exterior platform angle all affect the length and thickness of flakes that are produced.

Dibble and Pelcin (1995) continued this research and attempted to determine the impact that the mass of the hammer and the velocity of the blow had on the size (mass) of flakes. They concluded that the mass of a flake was determined largely by the characteristics of the striking platform, specifically the exterior platform angle and platform thickness. Based on these variables, Dibble and Pelcin (1995) devised a flake mass predictor equation that could be used to determine the original size of the flake from characteristics remaining on a reduced flake tool.

Criticisms have been levied against these experiments based on their artificial design and their lack of applicability to archaeological cases. Davis and Shea (1998) tested the results of earlier experiments and agreed that, while there is a correlation between flake attributes and the mass of the flakes that are produced through hard hammer percussion, exterior platform angle and platform thickness seemed to consistently overestimate original flake mass. They tested

Dibble and Pelcin's (1995) mass predictor equation by applying it to a more archaeologically realistic case. Davis and Shea (1998) produced a collection of obsidian flakes that were then subjected to simulated use and resharpening episodes in order to determine how well the predictor equation estimated original flake mass. Their results demonstrated that, while the relationship of platform area to flake mass is positive and significant, the relationship is not a linear one. As platform size increases, flake mass also increases, but at a much slower rate.

Dibble (1998) embraced many of Davis and Shea's (1998) criticisms but continued to be adamant that exterior platform angle, platform thickness, and platform width exert a strong influence on flake mass and dimensions. Dibble became less optimistic, though, that original flake mass could be reliably estimated in archaeological assemblages because of the high degree of random (human) error introduced by flintknappers. He also doubted that the ratio of predicted mass to remaining mass could be used as an index of reduction, because most of the mass of a flake is concentrated in the bulb of percussion and, therefore, lateral flaking will remove relatively small amounts of material (mass). It may, therefore, be more useful to examine changes in the surface area of the flake.

While these experiments encouraged analysts to consider how flake characteristics are produced, they were problematic because of their controlled and artificial natures. Shott et al. (2000) argue that little consideration was given in these early experiments to the impact of variables such as raw material type, core size, and core form. Shott et al. (2000) performed another set of experiments that used a variety of raw material types, mimicking the variety that might be encountered in an archaeological assemblage. They concluded that the regression equations that were devised in earlier experiments appeared to have little predictive value. They suggested that, while these equations might provide adequate models for understanding the

general relationship between flake size and platform size, they cannot be used to estimate the size of individual specimens.

It is apparent that problems exist with these early experiments, despite the fact that they may serve to provide basic models for understanding production of flake characteristics. A significant problem, though, lies in the ability of these models to predict the degree of reduction among tool types that are not simple flake tools. The experiments discussed above, as well as more recent reiterations of them (see, for example, Clarkson and Hiscock's 2011 paper on using 3-D scanners to determine platform area), all suffer from a similar, fundamental pitfall. Each was designed to allow interpretation of how much mass had been lost from the original flake blank through episodes of resharpening. That loss in mass serves as a proxy for understanding the degree of resharpening experienced by a tool. The problem is that many of the more formal classes of tools, both unifacial and bifacial, were produced by first reducing the original blank into a desired form by shaping the margins, removing unwanted bulk, etc. This unmodified tool was then subjected to episodes of use and resharpening. The newly minted tool, therefore, may bear little resemblance in dimensions or weight to the original blank size/weight. While applying these models might provide insight into original blank characteristics, they are less useful for understanding the nature of the newly produced tool and how much material was removed through *tool resharpening* as opposed to during *tool production*.

For formal tools, being able to estimate the size or mass of the original *blank* is not the concern. Instead, we should be focused on understanding how much material has been removed from the original, unresharpened *tool* form. It is useful to consider the issue of tool reduction in two parts: the reduction of simple flake tools and the reduction of more formal unifacial and

bifacial implements. To tackle the problem of formal tool reduction, we may turn to an examination of the variability in tool sizes, tool shapes, and other tool attributes.

Certain researchers have addressed these problems and have devised other measures of tool reduction for more formal flake implements. Morrow (1997), for example, considers the changes that occur in the form of formal, tapered Paleoindian end scrapers. She notes that, with reduction, we see decreases in tool length accompanied by decreases in tool width. Changes in the width occur because these end scrapers taper toward their proximal ends, so as material is removed from the distal end, the maximum width becomes progressively reduced. Among non-tapering specimens, we should not expect to see such a dramatic reduction in width. Morrow (1997: 77) and Ellis and Deller (2000: 102-107) argue that end scrapers should also exhibit reduced bit convexity and a corresponding increase in the steepness of the bit angle as the tool is resharpened. These patterns occur because, as the tool becomes shortened during resharpening, eventually the resharpening flakes cannot be removed from the corners of the bit, where the tool meets the haft or binding. If tools are held in a socket haft (i.e., a haft that has been hollowed out in the middle to house a tool; the edges of the haft completely enclose the proximal end of the implement), retouch can eventually be applied only to the highest point of bit convexity, toward the center of the bit. End scraper bits therefore become flatter as only the convex central portion of the bit can be retouched. Those tools that were hafted in split hafts (i.e., a piece of material that is split lengthwise, with the tool inserted between the two “prongs” that are formed; lateral margins of the tool may project beyond the width of the haft) may be more easily subjected to successive resharpening episodes.

The bit becomes steeper as a result of the nature of the resharpening flakes that are removed. Flakes tend to be thicker at their proximal ends and thinner near their terminations.

Resharpener flakes are detached from the dorsal surface of these tools by using the flat ventral surface as the platform. As long as the toolmaker can continue to remove flakes at an appropriate flaking angle, the desired bit angle may be maintained. Once the bit begins to approach the juncture with the haft, and becomes flatter, flakes may not be able to travel as far onto the dorsal surface. The thicker proximal ends of the resharpener flakes begin to approach the haft, and flakes are removed at a steeper angle, creating a steeper bit through resharpener. We may, therefore, assess the degree of end scraper reduction by considering the relationships among tool length, bit convexity, and bit angle.

Other flake tools do not possess working edges that can be assessed in the same way. Side scrapers, for example, may exhibit variability in the shapes of their working edges, and the resharpener of these edges is not limited in the same way by contact with the haft. Kuhn's (1990) Geometric Reduction Index for unifacial tools provides one potential solution to this problem. While Dibble (1987a, 1987b) had attempted to devise methods for interpreting unifacial tool reduction prior to the development of Kuhn's method, these previous attempts suffered from particular limitations. Dibble's (1987a, 1987b) method used platform dimensions in order to predict original flake blank dimensions, but Kuhn (1990) argues that, while an association does exist between platform size and overall flake size, platform size does not estimate *linear dimensions* reliably. Dibble (1987a, 1987b) also referred to the presence of particular types of retouch in order to assess degree of reduction, but, as Kuhn (1990) argues, using such a method requires some standardization of variable classifications in order for data to be comparable.

Kuhn (1990: 584) argues that a technique for assessing the degree of reduction should make no assumptions about reduction sequences and should not depend on the size of the

artifact. He devised what he describes as a “reasonably precise and replicable index of reduction for unifacial artifacts” (Kuhn 1990: 584) based on assumed characteristics of flake geometry.

Flakes tend to exhibit cross-sections that are essentially triangular: thicker toward the longitudinal center of the piece, and thinner at the lateral margins. As reduction of the unifacial implement progresses, “the retouch scars approach the centerline of the flake. The vertical thickness of the flake at the termination of the retouch scars (t ...) also increases, achieving the same value as the maximum thickness (T)” (Kuhn 1990: 584). The ratio of t/T may then be used as an index of reduction, with values closer to 0.0 indicating no reduction, and values approaching 1.0 indicating advanced reduction.

Measuring t can be problematic, though, as curvature of the ventral surface can make it difficult or impossible to take appropriate measurements. Kuhn suggests that it is possible to calculate a reliable estimate of t using measurements of the edge angle (retouch angle) and the depth of retouch (i.e., how far retouch scars extend in from the tool edge). The value of t can be calculated as follows:

$$t = \sin a (D),$$

where a is the angle between the ventral surface of the specimen and the retouched tool edge, and D is the depth of the retouch scars. The Index of reduction (I) can then be calculated as:

$$I = \frac{\sin a (D)}{T}$$

Kuhn (1990) addresses certain sources of error in his proposed methodology. First, he recognizes that real flakes do not always possess such an idealized form, and variations in flake form can alter the rate of change in the ratio of t/T . For example, if dorsal facets are particularly concave, then the ratio will change slowly at first and much more rapidly as retouch progresses.

Second, he suggests that differences in the steepness of the dorsal facets, which are related to differences in flake thickness, will also affect the rate of change in the t/T ratio. The analyst must consider whether flakes are thin and flat (slower increase) or thick and steeply angled (more rapid increase). Third, the location of the point of maximum thickness may influence the ratio, particularly if the thickest point is off-center. Such skewed flake geometry would mean that reduction along the thinner edge would take longer to reach the point of maximum thickness, making it appear as though a highly reduced specimen was much less reduced. Finally, errors in measurement and the natural variability in flake dimensions contribute additional sources of error. Kuhn (1990) argues that these latter errors may be minimized by taking measurements from multiple points on the tool, or by using mean values. I pursued the latter approach, measuring both retouch angle and flake scar depth at several points along the tool margin.

Because the production of bifacial implements involves an even greater degree of initial reduction of the blank or core into the tool, compared to the production of unifacial or simple flake implements, the methods for assessing degree of resharpening that are applied to flake tools are not applicable to bifacial tools. Examining changes in linear dimensions and in certain morphological characteristics is more informative for interpreting the degree of bifacial implement resharpening. Hafted bifaces (i.e., projectile points, knives) exhibit a variety of changes in size and morphology as they proceed through rejuvenation cycles. These tools tend to become narrower as edges are resharpened. Eventually, resharpening may begin to remove some of the original length of the tool, and with this reduction in length comes an increase in the angle of the tip. Some hafted bifaces also exhibit alternate beveling as a result of the toolmaker resharpening an edge, flipping the hafted specimen over and resharpening the alternate margin on the opposing face. While the presence of alternate beveling demonstrates that a hafted biface

likely has been resharpened, it does not suggest the extent of resharpening. To consider the degree of rejuvenation it is more useful to consider the abovementioned changes in size and morphology.

Other bifacial implements, such as drills, undergo changes in length through resharpening. As drill points become damaged through use, the tips must be rejuvenated, a process that removes material from the length of the implement. To assess degree of resharpening, it is useful to compare bit lengths within classes and within temporal categories.

While a consideration of resharpening flakes found in float samples from features and column samples provide direct evidence of resharpening as an activity being carried out at the site, it does not enlighten us about the degree of resharpening experienced by individual artifacts or classes of tools. Instead, it may provide insight into technological and other activities being carried out at the site, and therefore may be used to interpret site function.

CONCLUSION

In this chapter I have presented an overview of the methods used to record and assess changes in the technological aspects (i.e., design and production) of the stone tools from Dust Cave. In addition to considering how these designs and production strategies changed, it is also important to consider how tool *function* changed through time. Earlier in this dissertation I introduced the notion that certain tool classes persisted through time at the site while others either appeared or disappeared from the assemblage. Analysis of the subsistence data from Dust Cave has revealed both strong continuities and significant changes through time in certain aspects of subsistence behavior. Because we tend to view technologies as a means for humans to interact with their environments and to solve problems posed by those environments, it is

reasonable to assume that change or continuity in behavior, including subsistence pursuits and technologies, likely reflects change or continuity in the environment and in the problem-solving strategies employed by humans. In order to appreciate fully the consistent or changing roles of particular artifact classes within the settlement-subsistence system and how those roles reflect broader environmental conditions and behavioral concerns, I turn to an assessment of tool function over time. How were particular tool classes being used? Were they utilized in a consistent manner over time, or were the same tool types fulfilling different needs in different periods? Were different artifact types being produced to fulfill the same needs in different periods? And how can these functions enlighten us about the changing design constraints being faced by prehistoric toolmakers who were coping with a shifting natural and social environment? In the following chapter I present an overview of the history, theoretical underpinnings, and methods of macroscopic and microscopic use wear analysis and discuss how wear patterns can be used to interpret prehistoric tool function.

CHAPTER 6: METHODS – FUNCTIONAL ANALYSIS

In this chapter, I discuss the application of macroscopic and microscopic methods for assessing tool function. I present an overview of the history of functional studies, the theoretical basis for the microwear approach, and the various methods and analytical techniques that have been devised. I describe the various wear traces that can be observed and how those traces relate to prehistoric tool functions. Finally, I outline the implementation of the sample selection methods I used in this project.

I pursue functional analysis in this dissertation in order to understand more fully the role that certain tool classes played within the technological organizational scheme, and how those roles changed over time. Results of functional analyses serve to indicate both the activities in which those tools were being used and the materials that were being worked. In addition to a consideration of working edge design (e.g., edge shape and edge angle), I employ microscopic use-wear analysis, which considers wear traces that remain on tool edges after use. These analyses provide insight into use motion (direction of use), relative hardness of the worked material, and even the specific material that was being modified. I apply this analytical technique to certain classes of artifacts, including the various unifacial implements, as well as the intentionally and unintentionally modified flakes, in order to assess the uses in which these various tools were applied. I am particularly interested in whether there is overlap in their functions, or whether these more and less formal implements are representative of entirely different activities.

FUNCTIONAL ANALYSIS: BACKGROUND AND IMPLEMENTATION

In the early history of lithic analysis, issues of tool function were of little concern to researchers who were focused primarily on constructing archaeological “cultures” based on temporal and spatial associations of artifacts (Keeley 1980: 1). In the 1950s and 1960s, certain Paleolithic archaeologists who had been creating these archaeological “culture” classifications, began to ask whether differences in the proportions of various artifact types might be indicative of different tasks being carried out (e.g., Binford 1972; Binford and Binford 1966), rather than of the presence of distinct cultural groups (e.g., Bordes 1961, 1979; Bordes and de Sonneville-Bordes 1970). To test this functional hypothesis it became necessary to obtain “detailed data on how stone implements were actually used and on what materials they were used” (Keeley 1980: 1).

Attempts have been made to interpret prehistoric tool function through the application of ethnographic analogy, through which observations of ethnographically known tool forms and their uses are applied to an interpretation of the functions of similar prehistoric tool forms. Some researchers (e.g., Kamminga 1979) have even made ethnographic observations of tool use and studied the wear patterns on tools with “ethnographically verifiable functions” (Andrefsky 1998: 5). These ethnographic approaches are not without their pitfalls. First, the number of ethnographically known hunter-gatherer groups represents a small and not entirely representative selection of the full range of forager populations that existed prehistorically. More recent hunter-gatherer societies are geographically restricted and tend to live in marginalized and often extreme environments (e.g., Australia, parts of sub-Saharan Africa, the Arctic; see, for example, Binford 1978; Gould 1980; Lee 1979). Prehistoric hunter-gatherers, on the other hand, were found in all areas of the world, living in a wide variety of environmental contexts. Certain

prehistoric groups, such as those that existed at the end of the last Ice Age, would have experienced environmental conditions that possess no modern analogs. These populations would have faced adaptive challenges unlike any that modern hunter-gatherer populations face, and they likely engaged in activities that were unlike any that modern observers have recorded.

Second, most ethnographically recorded populations have experienced at least some degree of contact with the industrialized world, and many have adopted metal tools in place of stone implements or continue to use only a limited range of stone tools (especially non-formal tools; Brandt 1996: 733) and for a limited set of purposes. Therefore, the activities observed among modern hunter-gatherer groups are not necessarily representative of the full range of tasks in which stone tools were utilized prehistorically. By relying on ethnographic analogy for clues to tool function we may be receiving a biased perspective on prehistoric stone tool use.

One final problem with many lithic functional studies, including the early studies of stone tool chronologies and archaeological ‘cultures,’ as well as more recent considerations of tool function, is the lack of attention paid to non-formal tools. There has been a tendency, in stone tool studies, to focus on formal implements, especially those that have the potential to be temporally diagnostic. But as sites like Dust Cave demonstrate, many prehistoric stone tool assemblages are replete with non-formal and often quite simply designed implements. It is clear, from the sheer number of these tools, that they formed an important component of the technology, and yet comparatively little has been written regarding their functions. Their less formal and often rather amorphous nature makes it difficult to rely on equating formal characteristics with inferred functions.

For all of these reasons, it became necessary for lithic analysts to develop more objective methods for interpreting stone tool function. In the early 20th Century, the Russian archaeologist

Sergei Semenov began to develop such methods, which allowed interpretation of stone tool function through microscopic examination of wear traces that remained on utilized tool edges. While Semenov's methodology became the foundation for modern functional analysis, he was by no means the first to observe wear traces on stone tools.

Sven Nilsson, in the late 1830s, was the first to suggest the possibility of interpreting tool function from remaining wear traces (Vaughan 1981: 11). By the latter part of the 19th Century, several researchers had begun making observations of damage related to stone tool use. Rau (1864) observed striations and polish on stone hoes, while Greenwell (1865; in Cotterell and Kamminga 1979: 158) advanced an interpretation of end scrapers as hide dressing tools, based on the position and nature of damage and wear. He suggested that intense friction during use was responsible for smoothing the distal edges of these implements.

Evans (1872), who can be called the father of microwear studies, performed experiments using a variety of implements such as hoes, knives, scrapers, and simple, unretouched flake tools, and observed the types of damage that resulted from various tasks. He noted that prolonged use of blade margins tended to produce polish and suggested that similar activities may have been responsible for producing the polishes detected on prehistoric implements. Evans observed that scraping produced microchipping that was oriented perpendicular to the working edge, and that the size of microchips seemed to vary according to the amount of pressure applied to the worked material. He also considered "multiple causes for the same wear traces and similar tool types serving very different functions" (Kooyman 2000: 152).

By the late 1800s to early 1900s, the notion of wear traces on tools received wider attention as the "sickle gloss debate" became prominent in lithic studies. Certain tools, interpreted as cereal harvesting implements, were found to exhibit high gloss patches along their

margins. Spurrell (1892) suggested that this polish was produced through silica particles in the grain stalks rubbing against the tool edge. Vayson de Pradenne (1919) tested this hypothesis through experimental tool use and demonstrated that polish developed through both cereal harvesting and woodworking and, therefore, could not be attributed solely to plant harvesting activities. Curwin (1930) conducted another series of experiments in producing wood and straw polish and confirmed that these polish types could be differentiated. He established that woodworking produced a narrower band of polish along tool margins because the tool does not penetrate as deeply into the worked material.

At the same time as these other polish studies were taking place, Semenov was beginning his own study of both polish and striations (i.e., microscopic “scratches” on the tool edge). He published his results in Russian in 1957, but it was not until 1964 that his volume, *Prehistoric Technology*, was translated into English. This publication ushered in the modern era of microwear studies, which rely on microscopy to document and interpret use-wear traces (Kooyman 2000: 152). Semenov recorded important observations regarding the location and direction of striations, the extent of polish formation, and the position of microchipping associated with various worked materials and work actions. These three main categories of wear traces form the basis of modern microwear studies and will be considered in greater detail, below.

Semenov’s work grew into the two schools of modern microwear analysis: the low-power approach (Odell 1977; Tringham et al. 1974), and the high-power approach (Keeley 1974, 1976, 1980). The low-power approach utilizes a stereomicroscope, with magnifications generally no higher than 80x, and considers edge damage (microchipping) and striations. Examination of the form of flake scars and striations, as well as their orientation and distribution, can be used to

interpret relative hardness of the material being worked, the nature of the use motion (e.g., longitudinal or transverse action), and physical conditions in the work environment.

The high-power approach, on the other hand, makes use of incident light (IL) metallurgical microscopes, with magnifications between approximately 100x and 500x (Keeley 1974, 1976, 1980). Other high-power microwear studies have been conducted using scanning electron microscopes (SEM; e.g., Hay 1977; Mansur-Franchomme 1983) and laser scanning confocal microscopes (LSCM; Evans and Donahue 2008), both of which can produce even higher magnification powers. The emphasis in high-power studies is on polish development, which can be used to interpret the particular types of materials being worked.

These two approaches – high-power and low-power – were published independently and are often discussed separately, but Keeley (1980: 2) argues that the high-power approach should be seen as “complementing rather than replacing low-magnification examination.” The two approaches together, along with macroscopic observation of damage and tool morphology, provide the most complete insight into the functions of individual implements and tool classes.

The validity of microwear studies has come under some scrutiny. Tests of the low-power approach have shown it to be accurate, when compared to experimental results, but it is impossible to determine the precise nature of the material types that produced wear traces using lower magnifications. Tests of the high-power approach, on the other hand, have shown it to be “problematic, particularly when the tool was used to cut or scrape more than one kind of material” (Andrefsky 1998: 6). In other words, traces of tool use on one type of material can be masked or obliterated by the traces of subsequent use episodes on other material types, making it impossible to identify more than a single episode of use and a single worked material.

Some researchers have argued that micropolish analysis cannot be reliably used to discriminate tool function. Grace et al. (1985), Newcomer et al. (1986), and Rees et al. (1991) have all critiqued the reliability of micropolish analysis. Kooyman argues, however, that polish is viewed too simplistically in these critiques. Opposition to the utility of micropolishes as indicators of tool function tend to rest on the analysis of polish traces alone, while “Keeley (1980) and all subsequent micropolish analysts (e.g., Vaughan 1981) have clearly shown that worked materials are isolated by a *combination* of factors that include polish brightness, texture, contour, morphology, and features such as striations” (Kooyman 2000: 159, emphasis added). In other words, a holistic approach to microwear analysis, which takes into consideration not only the superficial appearance of polish but also various polish characteristics in concert with observations of other wear traces, provides researchers with the most comprehensive understanding of the forces and worked materials that produced the particular observable wear traces.

Other researchers have been significantly less pessimistic about the utility of polish studies. For example, Evans and Donahue (2008) utilized a Laser Scanning Confocal Microscope (LSCM) to demonstrate that, with the use of composite, laser-scanned images, various polishes appear distinct from one another and can be differentiated with relative ease. In addition to allowing reflected light scans of tool surfaces and edges, LSCMs can be used to take scans of various “slices” of the tool face, with a focal depth set below the surface so the scanner captures microtopographic detail. The LSCM then produces “high focal depth color images by combining color reflected light photomicrographs with LSCM slice data. These images are not simple photomicrographs but contain topographic surface data, which can be studied in numerous ways” (Evans and Donahue 2008: 2226). While SEM has been used in microwear analysis for several

decades (e.g., Mansur-Franchomme 1983) to produce high-magnification, highly detailed images of wear features, LSCM maintains some advantages over SEM. Preparing specimens for scanning electron microscopy requires coating the item in gold and mounting it to a specimen stub for observation, neither of which is a desirable option for most archaeological samples. Also, the specimen must be observed within a vacuum chamber whose dimensions are limited, thus restricting the size of items that can be observed. LSC microscopy, on the other hand, entails no such mounting requirements or size limits and, therefore, may be preferable for investigation of archaeological specimens.

Whether or not ILM-based polish analysis can reveal the exact type of material that was worked, it can reveal the presence of patterning among artifacts, which, when considered in association with other wear traces (striations, microchipping), may suggest whether groups of tools that I have partitioned into various techno-morphological classes can also be considered to represent similar functional classes. In other words, consistency in microwear patterning may indicate that a group of tools were being utilized in a similar way and, therefore, may provide additional support to a typology.

UNDERSTANDING AND IDENTIFYING WEAR TRACES

In the above section, I introduced the three main wear traces that have been used in the study of prehistoric stone tool use: microchipping, striations, and micropolishes. In addition to these three most often cited types of wear, tool function may be interpreted by considering the degree of edge and ridge rounding, as well as the presence of certain residues (e.g., phytoliths, blood residues). While I also consider edge rounding in my interpretation of tool function, I have not performed residue analysis on any of the tools from Dust Cave.

In this section, I consider how each of these forms of wear is created, what each of them can reveal about the nature of the materials being worked, and how to identify particular worked materials from wear characteristics. Images of these types of wear traces are presented in conjunction with my analysis of the Dust Cave materials in Chapter 8. Very briefly, characteristics of the microscarring demonstrate general tendencies in use motion and the density or hardness of the worked material. While the particular nature of the microflakes can suggest that the tool was used to work a “harder” or “softer” material, it is not a reliable indicator of the specific material that was worked. Both striations and the degree of edge or ridge rounding are indicative of the kinematics of tool use (Vaughan 1985: 46), and the degree of rounding can be studied to interpret the work intensity or relative length of time over which a tool was used. With the exception of worked material residues, micropolishes are the only wear traces that enable identification of the specific substance that was worked by a given tool, as “their formation is dependent primarily on the contact material” (Vaughan 1985: 46), rather than on length or intensity of use, the nature of the working environment, etc. While we tend to discuss diagnostic polishes as segregated units, there can be great overlap in polish formation.

It is important to remember that the patterns I discuss in the following pages are the prevalent tendencies when certain materials were worked, rather than the absolute rules. In order to produce the most reasonable assessment of wear patterns and the motions and materials that created them, it is necessary to consider all microwear traces together, along with macroscopic indicators such as impact or edge damage and tool morphology. Even when all possible traces are taken into consideration, interpreting wear patterns can be complicated by the fact that many nonuse-related factors produce wear that mimics the damage created through intentional use. I

discuss these factors below and consider how we may differentiate between use-related and nonuse-related traces.

In studying prehistoric stone tool assemblages, it is also important to bear in mind that experimental studies such as those conducted by Keeley (1980) and Vaughan (1985) have demonstrated that, even through episodes of relatively heavy use, many pieces never display much, if any, evidence of wear. This resistance to wear formation is largely related to the nature of the raw material used in tool production. It therefore is necessary for the analyst to become familiar with the range and nature of the raw materials within the sample. In the following section, in which I outline the implementation of my methods, I consider how to select those pieces that have the greatest potential to reveal interpretable wear traces.

Microchipping

Much of what we know about microchipping comes from the work of Odell (1981), Vaughan (1981) and Kooyman (1985). By considering characteristics such as their distribution, size, shape, and distal terminations it is possible for analysts to interpret from microflake scars the relative density of materials being worked, and the motion of use (Vaughan 1985).

For the purposes of interpreting the production of microflake scars, worked materials are divided into “hard,” “medium,” and “soft” categories (see Table 5.1). Harder materials include substances such as dry antler, dry wood, and bone. Working these types of materials tends to produce larger microflakes that exhibit step and hinge terminations and that exhibit shallow proximal cross-sections. Softer materials, including those categorized in Table 5.1 as “medium-soft,” tend to produce smaller microflake scars with feather terminations. Vaughan (1985) notes,

however, that there is great variability in the flake scars produced through working these softer materials.

Table 6.1: Worked Material Hardness Categories and Corresponding Characteristics

Hardness Category	Worked Material Examples	Characteristics
Hard	Dry antler, bone, dried wood	Larger scars; step and hinge terminations; shallow proximal cross-sections
Medium	Fresh/soaked hardwood, fresh/soaked antler	
Medium-Soft	Soft woods, dry hides, reeds, grasses, dried meats	Smaller scars; feather terminations
Soft	Meat (without bone), fresh hides, non-fibrous green plants	Smaller scars; feather terminations

Use actions, which include transverse, longitudinal, boring, and chopping motions, can be interpreted on the basis of the distribution of flake scars on the dorsal and ventral surfaces of the working edge. Transverse actions include scraping, planning, and whittling. Tringham et al. (1974: 188-189) noted that transverse motions tended to produce scars on only one surface of the working edge, with microflakes being detached from the surface opposite the face that was in contact with the worked material. The substance being worked essentially acts as an “indenter,” similar to a pressure flaker, applying force to one face of the working edge, and removing flakes from the opposite face. Odell and Odell-Vereecken (1980: 98) also recorded this unifacial microchipping as a result of transverse actions, with flakes being removed on the trailing face (i.e., the noncontact edge). Transverse motions also tend to produce dense, continuous scarring (Vaughan 1985: 20).

Longitudinal motions include actions such as cutting and sawing and tend to produce bifacial edge damage (Tringham et al. 1974: 188; Odell and Odell-Vereecken 1980: 98). These scars are often oriented diagonally to the working edge and exhibit variable distributions according to the angle at which the tool contacted the worked material. Thus scarring may be clumped or discontinuous.

Boring (e.g., drilling, perforating) and chopping actions produced bifacial scarring in the experiments carried out by Vaughan (1985).

It is important to recall that these observations represent only *tendencies* rather than rules and that the various experimental programs have recorded exceptions to all of these patterns. Vaughan's work has even demonstrated that many tools do not show signs of microscarring, even after periods of use, which "stands in contrast to the claim that 'scarring is the first to occur with utilization' (Odell 1975: 23)" (Vaughan 1985: 23). Particular types of materials (e.g., quartzite) are more resistant to microchipping, and certain worked materials will have more or less impact on tool edges. Softer materials, especially (e.g., meat, fresh hides), may leave tools virtually undamaged even after extensive periods of use (Kooyman 2000: 156).

Vaughan cautions analysts that we "cannot rely on microchipping *alone* to assess the modes of utilization (principally work action and hardness of the worked material) of prehistoric flint tools because of the large degree of variability inherent in microscar attributes and patterning" (1985: 23). He argues for a more holistic approach that considers microchipping in association with striations, edge rounding, and polishes.

Because factors other than tool use can produce microchipping, we must consider how to distinguish between those microflakes produced as a result of use and those that result from deliberate, secondary modification. Various experiments have demonstrated that use-related

microflakes tend to be smaller than intentionally produced secondary flake scars, with 2-3 mm (Kooyman 2000: 153-154) being the accepted limit. Any larger scars likely represent intentional secondary modification, although materials that are more easily flaked may produce larger use-related microscars. It can be difficult to distinguish use-related microchipping from the very smallest secondary flake scars. Vaughan's (1985: 24) experiments demonstrated that nonuse scarring, produced through forces such as trampling, movement of the tool in the screen, crushing in bags, and spontaneous retouch (i.e., microflake removal during intentional lithic reduction) tended to be random "with respect to surface, distribution, scar cross-section and size." Therefore, one key step in differentiating use-related and nonuse microscarring is to search for patterning, or lack thereof, in microflake characteristics.

Striations

Striations are simply scratches on the tool edges and surfaces that are caused by introduction of grit (e.g., sand grains), microchips, or pieces of the worked material (e.g., phytoliths) into the work environment. Striations are formed when these gritty substances contact the tool as it moves during use and, therefore, are useful for recording the direction of the work action. Vaughan (1985: 24) identified three morphological classes of striations during his experiments: deep striations, superficial striations, and directional indicators. Deep striations are recognized as grooves in the surface of the stone raw material and exhibit depth when examined microscopically. Superficial striations occur within patches of polish but do not cut into the surface of the chert. Directional indicators "constituted features that were an integral part of the surface of micropolishes" (Vaughan 1985: 24). In his experiments, Vaughan (1985) produced

deep and superficial striations but also noted a complete lack of striation development on many specimens.

Striation depth is an indicator of the density of the stone raw material, as well as the amount of pressure applied during use, which itself is a result of the use action and the flexibility of the worked material. Working harder materials produces more microchipping, which creates more abrasive particles that produce striations. For example, when soft hides are worked, few microflakes are detached and, therefore, few striations are produced.

The orientation of striations provides insight into the direction of tool motion. Transverse actions tend to produce striations perpendicular or diagonal to the working edge, whereas longitudinal actions produce striations parallel or diagonal to the working edge.

The distribution of striations can be used to interpret which tool edge came into contact with the worked material, which itself can provide insight into the nature of tool use motions. In general, transverse actions (e.g., scraping) produce striations only on the contact edge. If the tool was held at a steep working angle, striations might be noted on the noncontact surface as well. Longitudinal actions (e.g., cutting, sawing) sometimes produced striations on both faces, as both faces of the edge contacted the worked material while incising into it (Vaughan 1985: 25).

Analysts may face difficulties in attempting to interpret striation patterns, as forces other than tool use can produce scratches on the tool surface. It is necessary, therefore, to understand how to distinguish between use- and nonuse-related production of striations. Artifacts come in contact with abrasive substances through a variety of natural and artificial or accidental processes. These include movement of artifacts in the soil, movement of artifacts by water action, damage incurred as a result of trampling, movement in the screen during excavation, and cleaning in the lab (Vaughan 1985: 25). Striations from nonuse actions can appear either random

or patterned, but they can be distinguished easily from those produced through intentional use. Striations from use appear along the utilized tool margin, whereas striations from nonuse actions appear on the surface of the tool and along flake scar ridges, which would not have been utilized. In the case of nonuse striations, they also appear over much larger areas compared with the more restricted patches of use-related striations.

Rounding

Through intentional use, tool edges become rounded as continuous friction smooths the sharp margins. The working edge surfaces on which rounding is detected can reveal use action. Transverse actions tend to produce more rounding on the contact surface when the contact angle is moderate, and on the dorsal and ventral faces of the utilized edge when the contact angle is steeper (Vaughan 1985: 26). Rounding is also visible on both surfaces of the utilized edge if tool motion was longitudinal.

Intensity of the work action can also be deduced from the degree of edge rounding, as stone tool edges become more abraded through prolonged use, “except where intentional edge modification intervenes or where excessive microchipping continually removes portions of the rounded working edge” (Vaughan 1985: 26). The degree of edge rounding is also a function of the nature of the raw material, with certain stone raw materials exhibiting greater resistance to abrasive forces.

Through his experimental program, Vaughan (1985) noted several general patterns:

- longer periods of use produced more edge rounding
- coarser-grained materials became rounded more slowly
- working harder materials produced rounding more quickly

- a greater amount of grit in the working environment produced more intensive rounding

Certain nonuse factors, including water rolling and movement of artifacts in the soil, contributed to the production of rounding but could be easily distinguished from use-related rounding by being present on tool edges and flake scar ridges (i.e., tool surface rounding). To distinguish use- vs. nonuse-related edge rounding, then, the analyst must consider ubiquitous vs. localized distributions of rounding patterns.

Micropolish

“Micropolish” refers to the development of a reflective surface, which is brighter than the natural luster of the chert, and is “produced by a combination of abrasion (removal of material) and deposition of silica (taken into solution from the tool surface and any silica in the worked material)” (Kooyman 2000: 156) during tool use. Tool use on any given contact material would have resulted in the higher points of the microtopography being abraded to varying degrees. The raw material surface would have become smoothed, allowing for greater reflectivity. Working certain silica-rich materials deposited a layer of dissolved silica over the surface of the worked edge, producing even greater degrees of reflectivity. Because different worked substances are more or less dense and abrasive, working these various materials produces differing degrees of reflectivity, and polished surfaces with different and identifiable characteristics.

Because the development of polish is also dependent upon the nature of the stone raw material, interpreting these micropolishes is contingent on understanding the nature of the unmodified chert surface. Polish categories are relative, meaning that work actions produce a surface that is *more* reflective than the surrounding material. It is, therefore, necessary for the analyst to familiarize himself with the microscopic appearance, specifically texture or grain

sizes, of the unmodified chert surface before attempting to identify polish traces. This first step in micropolish examination ensures that “an unusual textural pattern which is actually natural will not be mistaken for generic weak polish or for a developed or isolated patch of a developed use-wear polish” (Vaughan 1985: 27).

Patterns of micropolish reveal intentional use on particular categories of worked substances. Micropolish analysis involves distinguishing polishes produced by contact with various worked materials on the basis of: brightness or reflectivity of the polish; the texture and volume of the polished area; the extent of the polish patch, specifically how far into the interior of the tool surface it stretches; and the degree of linkage among polish patches (Vaughan 1985: 27). Vaughan cautions that analysts should be wary of small, isolated, bright patches, as these are more likely features inherent in the stone raw material rather than use-related polishes.

In his experiments, Vaughan (1985) noted that polish characteristics appeared to be quite consistent regardless of the particular stone raw material from which the tool was made. While discrepancies existed in the degree of polish development, the size of the polish area, and the speed at which polish developed, there seemed to be no difference in the diagnostic characteristics of various polish types. This observation seems to indicate that polish descriptions, by Vaughan (1985) or Keeley (1980), are applicable to any stone tools as long as the analyst considers raw material grain size in the sample under investigation.

Micropolishes develop in stages, from a generic weak polish, to a smooth-pitted polish, and finally to a developed polish. Generic weak polish tends to appear dull and flat with a lightly terraced, stucco-like surface (Vaughan 1985: 28). This polish, which is only slightly brighter than the natural raw material surface, can occur even after only limited contact but tends to be more easily distinguished on finer-grained cherts.

Smooth-pitted polish, which develops next, is smooth on the surface but is interspersed with micropits and pit depressions that leave dark interstitial spaces and contribute to incomplete linkage of the polish (Vaughan 1985: 28-29). In Vaughan's experiments, he noted that the smooth-pitted stage was short-lived, and most tools progressed quickly into the third and final polish stage.

The final stage of polish development produces further polish linkage and is the stage at which diagnostic surface features are most readily apparent. This highly developed polish tends to be restricted to the immediate edge margin, but with prolonged or particularly intense use it may extend onto the surface of the tool. Vaughan (1985: 29) noted that this final polish stage was achieved more quickly when harder substances were worked.

Polish tends to form first on the crest of the working edge, then progresses to the higher points of the microtopography that come into contact with the worked material in the edge area, and finally to the lower portions of the edge microtopography. With prolonged use, the polish may extend onto the interior surface of the tool, following the sequence of development on higher then lower points of the microtopography.

A single tool edge may exhibit various stages of polish development either if microchipping occurs along the edge and removes patches of developing polish or if differences exist in the texture of the chert surface that cause polish to develop differentially.

Polish types are classified according to the type of worked material. Below, I discuss characteristics of polishes that develop from working a variety of substances, including meat, animal hides, plant materials, and harder substances such as bone and wood. I also discuss the characteristic features of generic weak polish and smooth pitted polish. I consider how these

polishes form, how they are recognized, and how they can be distinguished from polishes formed through natural means.

Generic Weak Polish

This is a dull polish, only a little brighter than the natural chert surface, with a stucco-like, lightly terraced texture. It contains pit depressions, making it rougher than developed polish, but smoother (i.e., brighter) than the background microtopography. This polish usually is flat, generally lacking in volume, and tends to be distributed in small patches that are restricted to the immediate edge margin. Vaughan (1985: 30) notes that it is “difficult to distinguish from natural bright spots on the flint surface and from soil sheen.” While generic weak polish may indicate that a tool has been used, it is not diagnostic of any particular worked substance, instead representing the initial stages of most polish formation.

Smooth-Pitted Polish

Smooth pitted polish is characterized by incompletely linked, smooth-surfaced polish components on the higher points of the raw material microtopography. Between these small patches of smooth polish are dark interstitial spaces. The linked portions are “replete with micropits and pit depressions, which together with the interstitial spaces impart an overall roughish aspect to this stage of polish development” (Vaughan 1985: 30). The degree of linkage, the amount of pitting, and the size and volume of polish patches all vary according to the degree of contact with the worked material, including the length of time that the tool was used, and the density of the worked material.

Bone Polish

Working bone produces a bright polish with an overall pitted appearance (Vaughan 1985: 31). This polish tends to be significantly brighter than the natural raw material surface, and exhibits a rough, pitted texture. Bone polish often exists in isolated patches, being restricted to the high points of the microtopography. The greater density of bone as a worked material contributes to the restriction of polish to the edge margins, as the tool does not penetrate very deeply into the worked piece. Bone polish coverage, therefore, typically is not extensive.

Working this hard substance removes many microflakes, which produces abundant striations (Kooyman 2000). Transverse actions produce a flat polish bevel along the worked margin, while longitudinal actions often exhibit polish on both the dorsal and ventral faces of trihedral edges. Longitudinal work actions (e.g., sawing) also create “numerous troughs and grooves running through the larger components, indicating the relative direction of the use motion” (Vaughan 1985: 31).

Vaughan (1985) notes that it is quite difficult to distinguish bone polish from antler polish, although he noted in his experiments that antler polish tended to exhibit fewer linear indicators. Bone polish can also mimic well-developed wood-sawing polish.

Antler Polish

As discussed above, antler polish may resemble bone polish and can only be differentiated if it is well linked. With high degrees of linkage, antler polish is quite different from bone polish, exhibiting a smooth surface with “diffuse depressions which impart a gently undulating look, or the appearance of a ‘melting snowbank’ in L. Keeley’s words” (Vaughan

1985: 32). Vaughan suggests that, when observing archaeological specimens, the analyst may only be able to interpret a general category of “bone or antler.”

Sawing antler produces highly localized, but heavily linked, polish near the working edge. The undulating surface of the polish produces smooth, rounded bevels, unlike the flat bevel noted for bone polish.

Wood Polish

Both hardwood and softwood polishes are identical in appearance, but they develop at different rates, with softwood polish developing faster (Vaughan 1985; Kooyman 2000). Surface characteristics are otherwise identical under the microscope. Wood polish is slow forming compared to other polish types, such as bone polish. Its development progresses from a generic weak polish to smooth, individual polish domes on the higher points of the microtopography. Those isolated polish domes develop more fully into “bulging and sagging domes...and next into an undulating polish cover...and ultimately with very extended contact into a smooth polish blanket” (Vaughan 1985: 33). Kooyman (2000: 157) describes these polish mounds as “snow bank-like” and containing many striations.

Even in its early stages, wood polish is always very bright. As the polish forms, pit depressions are eliminated and areas of polish become more fully linked, with areas of polish filling in hollows in the microtopography and appearing glassy in its most extreme presentation. Because wood is a more pliable substance than either bone or antler, polish development may extend onto the surface of the tool as it penetrates deeper into the worked substance.

In transverse and grooving actions, wood polish exhibits bright, smooth domes of variably linked polish, with “vague interdome ‘valleys’ indicating use direction” (Vaughan 1985:

34). Boring actions produce various stages of polish on the lateral margins and dorsal flake scar ridges of the borer.

Plant Polish

Working certain plants produces a very characteristic form of polish that, in its most developed state, is called “sickle gloss.” Plant polish forms slowly and proceeds through the various stages according to the length of time that a tool was used. Apart from variation in the speed of polish development, Vaughan (1985) noted no appreciable differences in his experiments with barley, cattail, and marsh elder in the polish characteristics that developed after working with each plant type.

Well-developed plant polish tends to be very bright and is pockmarked until it becomes completely linked in its most advanced stage. Working fibrous, silica-rich plants produces an extremely glassy and reflective surface when highly developed, as the silica in these plants dissolves and is redeposited on the surface of the tool. This polish forms on top of the chert surface and, as it develops, becomes widespread and invasive with a “flowing” appearance (Vaughan 1985: 36). While striations form in the solid polish surface, many become infilled through continued use, or produce “comet-tails” within the surface of the polish. These “comet-shaped pits are caused when ‘pits in the flint have had their edges rounded and wiped away, with their leeward sides hollowed out’” (citing Witthoft 1967: 384; in Vaughan 1985: 36).

Working softer plants with less silica content produced less reflective and poorly linked polish, with little alteration of the chert microtopography. This polish is smooth but does not exhibit the rounded polish domes or glassy appearance of the polish that is characteristic of working fibrous or silica-rich plants.

Tanned or Dry Hide Polish

Working tanned or dried hides produces a dull, pitted polish with many striations and extreme edge rounding. The polish forms in the process of scraping hair or tissue off dried or tanned animal hides. Through prolonged use, dry hide polish begins to appear rugose, with a highly pitted polish surface. Because the material is relatively supple, allowing the tool to dig into the hide more deeply, widespread polish forms quite evenly and continuously on both the leading and trailing surfaces. Extensive edge and flake scar rounding is quite diagnostic of dry hide polish (Vaughan 1985: 37). The rounded edges also frequently exhibit striations running perpendicular to the working edge, indicating a transverse (i.e., scraping) action. These striations become even more pronounced if hide working was conducted in a gritty environment (Driskell 1986).

Fresh Hide and Meat Polish

Polish produced through cutting meat or working fresh hides is not dramatic in appearance and tends to form very slowly in uneven patches along the edge margin. It tends to be dull, and is only a little brighter than natural raw material surface, being essentially a form of generic weak polish. Striations are rare and there generally is no rounding of the microtopography evident. Despite being dull, fresh hide and meat polishes tend to be well linked and extensive. With prolonged use, working these materials can produce a thin, bright band along the working edge, which appears under the microscope as a silvery ribbon that follows the edge margin (Vaughan 1985: 38). In some cases, patches of bright polish can be recognized, which are the result of bone contact during butchering (Kooyman 2000). Some microwear

analysts note that fresh hide and meat polishes exhibit a “greasy” luster, but Vaughan did not note this in his experiments.

The distribution of polish on tools used to deflesh hides was essentially “equal on both surfaces of the used flint edge, because removal of the fleshy tissues from the inside of a fresh animal skin is most efficiently accomplished by a slicing or shaving motion (i.e., longitudinal action) rather than a scraping action” (Vaughan 1985: 388). The same is true of polish development from cutting meat.

Butchering Polish

The nature of polish produced through butchering animal carcasses depends upon the relative amounts of bone, meat and skin contact. In general, butchering is recognized by the presence of a smooth, thin band of polish along the crest of the working edge, generic weak polish in the immediate edge area, and patches of bone polish along the edge (Vaughan 1985: 38). This polish generally is not extensive, as microchipping from bone contact removes polish as it forms.

Polishes from Prehension and Hafting

In addition to polish that is produced through contact with worked materials, polish may form on tools as a result of contact with a haft or with the toolmaker’s hands. Vaughan (1985) noted very little finger prehension polish on his experimental specimens and suggested that more may have developed with the introduction of more grit into the work environment. Hafts made of harder substances such as bone or wood may have produced edge crushing and patches of diagnostic polish. This polish would not have been restricted to edge margins though, as the

dorsal and ventral surfaces of the tool, as well as the proximal end, would have been in contact with the haft substance. Leather or sinew bindings may also have left identifiable hafting traces toward the proximal ends of tools. It is, therefore, important for the microwear analyst to examine not only the tool edges, but tool surfaces as well, if hafting is suspected.

Non-Use Polish Formation

Factors other than intentional use of tools can produce polish on archaeological specimens as well. Movement of the artifact in the soil will produce a generic, weakly developed polish all over the surface of the implement. If the artifact became subjected to water rolling action it may also develop polish on surfaces other than the used edges.

Polishes can also develop as a result of contact with percussors during the flintknapping process. Percussors made of bone, wood, and antler are more pliable and come into contact with the surface of the tool for so little time that polish development is minimal and may be masked by the development of soil sheen. Harder stone percussors (hammerstones), on the other hand, can leave smears of polish that are flat and dull to bright, with an uneven surface texture.

Archaeological recovery and processing can also produce reflective patches on stone artifacts, but these are, fortunately, quite easy to distinguish from use-related polish. Metal from contact with excavation equipment can leave traces that mimic polish. Metal smears appear as extremely bright, generally isolated patches that often bear a metallic appearance (e.g., copper-colored). Through my own experiences with recognizing metal “polish,” I can say that these traces are brighter than any use-related polishes and have a “high contrast” appearance to them, with bright central patches that are often surrounded by a very dark looking outline.

The archaeologists and microwear analysts who handle artifacts from initial recovery through processing and analysis introduce finger oils onto the surfaces of tools, which produce reflective patches that can be mistaken for polish. Finger oils tend to leave an iridescent sheen on the surface, much like the appearance of oil slicks in puddles, and can often be identified by the recognition of small, round, brownish colored globules of fat within the areas of reflectivity. For this reason, it is important to clean artifacts properly and thoroughly before analysis. These procedures are detailed in the following section.

Another more confounding archaeologically produced “polish” to recognize, and one that was identified with some unfortunate regularity in the Dust Cave sample, is the presence of nail polish. Nail polish can be used to cover labels on artifacts as they are being processed in the lab. For the reason that nail polish is very difficult to distinguish from use-related polishes, it is advisable *not* to use it for labeling if microwear analysis is part of the intended research program. Nail polish appears very bright and smooth under the microscope and often bears linear indicators that mimic either striations or comet tails. With careful observation, though, it can be differentiated from use-related polishes. Nail polish exhibits a “plastic” look; while it is highly reflective, there is an underlying “flatness” to the luster, and it tends to exhibit an iridescent surface sheen. It may be removed easily with acetone, which leaves the surface of the tool clean and undamaged.

FUNCTIONAL ANALYSIS METHODS

From the discussion of wear patterns, above, it should be apparent that there is great variability in microwear traces. This variability arises as a result of differences in the worked material, differences in the length and intensity of use, differences in characteristics of the stone

raw material, effects of tool resharpening and reuse, effects of nonuse wear factors and handling/processing procedures, etc. Even among those artifacts that were subjected to use, many will not exhibit wear patterns for a variety of reasons. First, particular materials, such as meat or fresh hides, are not prone to producing well-developed wear traces. Second, other materials that are known to produce more apparent wear patterns may only do so after intensive or prolonged periods of use. Certain tools may have been used too briefly, preventing the development of substantial wear. Third, wear traces may be obliterated through resharpening of a dulled tool or through post-depositional taphonomic forces. Finally, some tools may have been lost to the archaeological record before they were even used. Tools that were cached and never recovered, or newly produced tools that were lost before they were ever used, will not show any patterns of functional wear.

When analysts consider a large collection of stone tools, like that recovered from Dust Cave, it is therefore important for the analyst to bear in mind that many of the implements will not exhibit any signs of wear. Because microwear analysis is a lengthy process, it is not generally feasible to conduct intensive analysis of thousands of artifacts, nor is it sensible, given the high proportion of tools that may not provide any interpretable wear patterns. To ensure that my efforts were spent in such a way as to generate the most valuable data possible, I relied on a stepwise sample selection protocol for identifying the pieces that were most likely to exhibit interpretable microwear patterns (see Rigney 2009). I discuss this method, below, as well as the procedures for preparing and recording specimens.

Functional Analysis Selection Protocol

My discussion of the various wear traces, above, has shown that working certain materials, especially harder/denser materials, and for longer periods of use, will tend to produce more easily detected wear patterns. For example, sawing a piece of bone is more likely to leave a distinct set of damage and wear patterns, including microchipping and polish, than is using a flake to slice a piece of meat quickly. Softer substances such as meat or fresh hides may produce polish on tools after extended periods of use, but there tends to be little accompanying edge damage. These general observations form the basis of the protocol I employed for selecting the artifacts to be subjected to high power, incident light microscopy.

Prior to selecting individual artifacts for microwear analysis, though, I selected the artifact classes that I felt would be most informative. Research has already shown that hafted bifaces, including those recovered from Dust Cave, tended to function either as projectile tips or as butchering implements. One more microwear study on this class of tools likely would not have contributed any new knowledge regarding tool function. Unhafted bifaces may have been used as hand-held cutting implements or remained unutilized, representing a preform stage for production of hafted implements.

Of greater interest, for the purposes of this study, are the functions of the unifacial and simple flake tools, including the functions of individual tool classes, and a comparison between the functions of the formal and less formal implements. In Chapter 2 I discussed shifts in tool representation through time at Dust Cave, highlighting the prevalence of formal unifaces in the earlier deposits, the disappearance of formal unifaces by the end of the Early Archaic, and a rise in the representation of bifaces and modified flakes in the Middle Archaic. In order to understand what this technological reorganization represents, it is useful to consider tool function. Are

different tool classes being used to carry out the same tasks over time (i.e., are tool users engaging in the same activities using different implements), or is the range of activities changing? Regardless of how the functions of various tool classes relate to one another, it is informative to consider the functions and range of behaviors represented among the non-formal unifaces and the expedient flake tools, two broad classes of artifacts that have been largely ignored throughout the history of lithic analysis.

The majority of the microwear analysis presented in this dissertation focuses on the flake implements, including formal and non-formal unifaces, and simple flake tools. I also examine certain bifacial implements such as the perforators and drills. While this initial selection reduced the number of tools to be examined, the sample was still too large to examine in a reasonable amount of time, and so I proceeded to subject this large collection of specimens to a stepwise selection procedure.

This stepwise process, as outlined by Rigney (2009), involves examining the artifacts first at the macroscopic level, then with the stereomicroscope, and finally with the incident light microscope, eliminating specimens that did not exhibit certain wear traces at the various levels of consideration. Macroscopic observation of the tools involves examining the implements with the naked eye, a 5X illuminated lens, or a 10X hand lens. I examined these tools for evidence of edge damage and wear traces, including crushing, microchipping, and even striations. If a tool was used to work a hard enough substance or was used intensively enough to produce edge damage, then there is a good chance that other wear traces will have developed as well. Conversely, if a tool was used to work a soft substance or for short enough periods of time so as to produce no edge damage, then it is likely that any other wear traces would be difficult or impossible to detect and interpret. Examining tools macroscopically for the presence of edge

damage also suggests what portion of the tool was utilized, which helps to direct high power microscopic examination. Those tools that did not exhibit any significant edge damage were removed from consideration, while tools that did exhibit macroscopic wear patterns were then examined microscopically.

Stereoscopic examination of the selected tools was accomplished using a Zeiss Stemi 2000 stereomicroscope capable of magnifications between 6.5X and 50X. Through examination of tool edges at this magnification, I recorded the distribution and characteristics of the edge damage that are suggestive of the motion of use and the density of the worked substance. Striations were also observed occasionally at this magnification, and in a few cases, patches of well-developed polish could be detected.

Specimens were then subjected to examination with the high power incident light microscope. This microscope, a Zeiss Axio compound microscope with 100W halogen differential interference contrast (DIC) lighting and Epiplan brightfield/darkfield objectives, is capable of producing magnifications between 50X and 400X. An initial scan of the piece was done at 50X, while the majority of polish identification was accomplished at 200X. I reserved the use of the 400X objective for more detailed inspection of certain polish features. High power examination of these tools was undertaken in order to identify polish patterns that are suggestive of the type of material that was worked. In addition to polish traces, striations and microchipping can be investigated in greater detail at these magnifications.

By using a stepwise selection procedure like the one outlined above, the originally very large collection of stone tools was reduced to a more manageable sample and one that was apt to produce more valuable data.

One exception to this procedure was in its application to the categories of Intentionally and Unintentionally Modified Flake tools. Because of the nature of the tools (i.e., tools that were identified as having been used but not modified extensively or at all), their very classification in these categories represented the first step in the selection process: macroscopic examination and selection of potentially utilized implements. After finishing this first stage of the selection process, there were still a large number of artifacts to be examined in both the Intentionally (n=149) and Unintentionally Modified Flake tool (n=555) categories. In order to select a more reasonably sized sample for microscopic examination, I first removed those specimens without secure chronological associations. Artifacts without temporal references contribute nothing toward achieving the goal of understanding changes through time in technology. Any artifacts without zone designations or carefully recorded depth measurements that could be correlated with depths and corresponding zones in adjacent units were removed from consideration. Even if these discounted specimens did exhibit wear traces, these patterns would not be helpful in interpreting diachronic functional changes.

The remaining sample of tools was still quite large, so I employed a system of stratified random sampling based on 20% random samples from each general zone. The general zones include only zone letter designations, and not the numbered sub-zones, which would have produced populations that were too small for sampling.

Functional Analysis Specimen Processing

Prior to microscopic examination, each specimen was subjected to a thorough cleaning regimen in order to remove any substances that might mimic wear patterns. Finger oils and other residues can leave traces that resemble polish, while dirt clinging to the surface of the artifact can

mask wear features. Following initial lab processing, which involved simply washing the dirt off the specimens using water and a soft bristled toothbrush, those specimens selected for microwear analysis were submerged in a solution of ammonia, gentle dish detergent, and warm water. After soaking the specimens for 10 minutes, I scrubbed each with a soft bristled toothbrush, and then washed them under running water. I rinsed the clean specimens in rubbing alcohol, which helps to remove any remaining cleaning solution and facilitates faster drying. Artifacts were left to dry naturally and then were wrapped in tissue and placed back into their labeled bags. Wrapping specimens helps to keep implements clean and serves as an indicator that the specimen has been processed for microwear analysis. Once the artifacts were clean, I handled them only while wearing gloves, to prevent further deposition of finger oils.

Specimens were examined macroscopically and under the stereomicroscope by simply holding the specimen. Examination of specimens using the incident light microscope, on the other hand, requires that the pieces be mounted. At such high magnifications, any movement is greatly exaggerated. Mounting the specimen therefore allows it to be moved by small increments on the x/y axis flat stage, and avoids the problems of minor hand movements. The specimens were mounted on glass slides using a piece of modeling clay covered in a layer of paper towel. The artifact can be seated in the soft modeling clay and held in place securely.

Recording Microwear Observations

As I observed the selected specimens, I recorded any wear traces that I noted in a form based on the stepwise selection procedure described above. These record forms, which are informal in nature, are modeled on those used by Boyce Driskell (1994, 1998; see Appendix B). Each record sheet included specimen information (e.g., accession number), a place for photos or

sketches of the specimen, and written descriptions of the macroscopic, stereoscopic, and incident light observations.

The specimen photos served as a “map” for recording the locations of particular wear traces on the tool. I labeled points where various wear patterns were located and described each location in the sections for written microwear observations. These descriptions are presented in Appendix B in the attachments to this dissertation.

CONCLUSION

In this chapter, I have presented an overview of the methods of functional analysis applied to the Dust Cave assemblage and the nature of observed functional wear traces. The results of my functional analysis, which are presented in Chapter 8, serve to provide additional insight into the changing nature of technological strategies at Dust Cave. I focused much of my analysis on understanding the roles played by specialized blade tools, formal unifaces, and simple flake tools. Blade implements are noted almost exclusively in the Late Paleoindian samples, while formal unifaces are known from the Late Paleoindian and Early Archaic levels. Simple, intentionally and unintentionally modified flake implements become much more common in the later assemblages and appear to have replaced the earlier dependence on formal unifaces. Functional analysis provides insight into the roles played by these various tool classes, how the functions of these tools related to one another, and how these roles changed over time. In the following two chapters, I present the results of the technological and functional analyses before considering technological changes in the context of shifting environmental conditions and settlement-subsistence strategies in the final chapter. The relationships among technology, settlement-subsistence behaviors, and environmental conditions provide an illustration of the

ways that humans exercise technological agency in order to adapt to particular and changing environmental circumstances.

CHAPTER 7: TECHNOLOGICAL ANALYSIS: RESULTS AND INTERPRETATIONS

In this chapter, I present my technological analysis of the chipped stone artifacts from Dust Cave and discuss the results of this analysis. In concert with the results of the functional analysis presented in the following chapter, this study allows me to interpret the ways in which technologies were being designed, produced, and used as organized solutions to adaptive problems posed by the natural and social environments during the occupation of Dust Cave. The data discussed here will provide insight into the ways in which technologies were designed in order to facilitate group survival under changing environmental conditions and will allow me to address how technological strategies enabled the Dust Cave toolmakers and tool users to engage with and exploit the environment efficiently.

This chapter presents a discussion of technological patterns, specifically the composition of toolkits, the design of implements and of broader artifact categories, the strategies of tool production, the nature of tools upon discard, and, most importantly, how all of these features of the technology changed or remained the same over time. Functional concerns, or the *use* of artifacts, will be considered in the following chapter. I begin simply by evaluating the types of artifacts that comprise the toolkits characteristic of each of the occupations represented at Dust Cave. Because it is being considered in isolation, the artifacts and corresponding activities represented at this site may or may not be representative of the full spectrum of site use patterns across the landscape at any given time. It is, therefore, important to recall that the range of artifacts recovered from Dust Cave represents only those artifacts that were discarded during the occupation of the site and, therefore, may not be representative of the full chipped stone tool inventory that was in use during any given period. Activities carried out off-site, during other

portions of the settlement-subsistence cycle, may have required the use of different artifact inventories than those deposited at the cave.

It is also important to recall that the implements discarded at Dust Cave may or may not have represented the activities being carried out at the site itself. If Dust Cave acted as a “retooling” station, then the tools that were deposited may represent the remains of activities that occurred elsewhere, during other parts of the settlement-subsistence cycle. Technological and functional analyses will serve to elucidate some of these issues.

In order to characterize the toolkits from each of the occupation periods, I consider the various classes of artifacts that were recovered from the levels associated with each of the five major periods of occupation at Dust Cave: Late Paleoindian, Early Side Notched, Kirk Stemmed, Eva/Morrow Mountain, and Benton. Each of these periods is considered separately where possible. In some cases, though, it was impossible to associate certain artifacts with specific zones. In the earlier seasons of excavation, detailed zone designations had not yet been devised, and so artifacts were associated with a more general level. For many of these specimens, I was able to consider depth measurements in association with the depths recorded for nearby known zones in order to provide a best estimate for temporal-cultural affiliation. These artifacts are classified into general “Early” (Late Paleoindian), Mid (Early Archaic), or Late (Middle Archaic) zones. I consider the presence and absence of various tool types at different times, as changing toolkit inventories are assumed to reflect changing technological needs, which themselves indicate broader adaptive concerns.

Table 7.1 presents tool counts for the various periods represented at Dust Cave. Artifact totals, by specific and general periods, are presented in Table 7.2. Catalogs of tools and their metric attributes are presented in Appendix A at the end of this volume.

Table 7.1: Artifact Type Counts and Percentages by TCA. (Specific Zones only. See Appendix A for tool lists.)

	Early Levels (Paleoindian)	Mid Levels (Early Archaic)			Late Levels (Middle Archaic)		Zone A
Tool Class	Mid and Late Paleoindian n (%)	Early Side Notched n (%)	Early Side Notched/Kirk Stemmed n (%)	Kirk Stemmed n (%)	Eva/Morrow Mountain n (%)	Benton n (%)	No TCA n (%)
ESB	1 (0.29)	2 (0.84)	0	0	4 (1.86)	6 (4.11)	0
MSB	10 (2.87)	2 (0.84)	2 (3.63)	3 (1.96)	8 (3.72)	5 (3.42)	0
TBI	17 (4.87)	36 (15.19)	7 (12.73)	26 (16.99)	27 (12.56)	13 (8.90)	2 (10.00)
TBII	36 (10.32)	28 (11.81)	14 (30.91)	26 (16.99)	55 (25.58)	29 (19.86)	3 (15.00)
HAB	14 (4.01)	62 (26.16)	1 (1.82)	33 (21.57)	42 (19.53)	71 (48.63)	12 (60.00)
PHB	8 (2.29)	1 (0.42)	7 (12.73)	2 (1.31)	11 (5.12)	2 (1.37)	1 (5.00)
DRL	5 (1.43)	5 (2.11)	1 (1.82)	6 (3.92)	4 (1.86)	0	0
ESCR	10 (2.87)	2 (0.84)	0	6 (3.92)	3 (1.39)	0	0
SSCR	8 (2.29)	0	0	0	1 (0.46)	0	0
HSCR	1 (0.29)	1 (0.42)	0	1 (0.65)	0	0	0
OSCR	8 (2.29)	1 (0.42)	0	0	0	0	0
GRV	6 (1.72)	1 (0.42)	0	0	0	0	0
PERF	0	0	0	1 (0.65)	2 (0.93)	0	0
UNF	36 (10.32)	14 (5.91)	1 (1.82)	1 (0.65)	2 (0.93)	0	0
RFL	41 (11.75)	24 (10.13)	3 (5.45)	3 (1.96)	8 (3.72)	2 (1.37)	0
UFL	89 (25.50)	52 (21.94)	17 (30.91)	43 (28.10)	23 (10.70)	16 (10.96)	2 (10.00)
BSCR	14 (4.01)	1 (0.42)	0	1 (0.65)	0	0	0
BLD	8 (2.29)	2 (0.84)	2 (3.64)	1 (0.65)	3 (1.40)	2 (1.37)	0
RBLD	20 (5.73)	2 (0.84)	0	0	0	0	0
UBLD	9 (2.58)	1 (0.42)	0	0	1 (0.46)	0	0
TOTAL	341	237	55	153	194	146	20

ESB = Early Stage Biface; MSB = Mid Stage Biface; TBI = Trimmed Biface I; TBII= Trimmed Biface II; HAB = Hafted Biface; PHB = Probable Hafted Biface; DRL = Drill; ESCR = End Scraper; SSCR = Side Scraper; HSCR = Humpback Scraper; OSCR = Ovoid Scraper; GVR = Graver; PERF = Perforator; UNF = General Uniface; RFL = Intentionally Modified Flake; UFL = Unintentionally Modified Flake; BSCR = Blade Scraper; BLD = Unmodified Blade; RBLD = Intentionally Modified Blade; UBLD = Unintentionally Modified Blade

Table 7.2: Total Artifact Counts by Period. (For counts and temporal cultural affiliations, see data in Appendix A.)

Specific Period	Artifact Count	General Period	Artifact Count*
Paleoindian	341	Early Levels	406
Early Side Notched	237	Mid Levels	645
ESN/KS Mixed	55		
Kirk Stemmed	153		
Eva/Morrow Mountain	194	Late Levels	766
Benton	146		
Zone A	20	Zone A (no TCA)	20

*Counts for General Periods include artifacts that could not be assigned to a specific period, but only to a general level, based on excavation depth.

GENERAL DATA OBSERVATIONS

General Artifact Counts

Before I consider the toolkits from individual periods, I present a brief discussion of some general observations based on the dataset as a whole. The collection analyzed here includes 2120 artifacts: 1161 biface implements (54.8% of the total assemblage), 859 flake tools (40.5% of the total assemblage), 66 blade tools (3.1% of the total assemblage), and 34 unmodified blades (1.6% of the total assemblage). While each of the 2120 artifacts was examined and recorded, not all were studied or analyzed in detail. The classes that received less attention, and the reasons for this lack of attention, are discussed throughout this chapter.

The collection of biface implements includes several artifact types, listed in Table 7.3, while the collection of flake implements is listed in Table 7.4.

In addition to these generalized flake tools, a collection of specialized blade tools was recovered from the site. The blade tool types are outlined in Table 7.5.

Table 7.3: Biface Type Counts. (Data available in Appendix A.)

Type	Count	%
Early Stage Bifaces (ESB)	14	1.2
Mid Stage Bifaces (MSB)	47	4.0
Trimmed Biface I (TBI)	296	25.5
Trimmed Biface II (TBII)	404	34.8
Hafted Bifaces (HAB)	297	25.6
Probable Hafted Bifaces (PHB)	64	5.5
Drills (DRL)	39	3.4
TOTAL	1161	100

Table 7.4: Flake Implement Type Counts. (Data available in Appendix A.)

Type	Count	%
End Scrapers (ESCR)	33	3.8%
Humpback Scrapers (HSCR)	6	0.7%
Ovoid Scrapers (OSCR)	11	1.3%
Side Scrapers (SSCR)	10	1.2%
Other Scrapers (ESCR/SSCR, SCR)	3	0.3%
Perforator (PERF)	5	0.6%
Graver (GRV)	10	1.2%
Multipurpose Uniface (e.g., GRV/SCR)	3	0.3%
General Uniface (UNF)	75	8.8%
Intentionally Modified Flake (RFL)	149	17.3%
Unintentionally Modified Flake (UFL)	554	64.5%
TOTAL	859	100

Table 7.5: Blade Implement Type Counts. (Data available in Appendix A.)

Type	Count	%
Blade Scrapers (BSCR)	18	18.0
Unmodified Blades (BLD)	34	34.0
Intentionally Modified Blades (RBLD)	28	28.0
Unintentionally Modified Blades (UBLD)	20	20.0
TOTAL	100	100

Artifact Counts by Period

Examination of the stone tool data from the various cultural periods at Dust Cave reveals several patterns worthy of discussion. First, if we consider the distribution of artifacts by individual period, rather than by general cultural stage (e.g., Paleoindian, as opposed to “Early Levels”), we see that the Paleoindian levels produced the largest number of chipped stone artifacts (n=349). Following the Paleoindian period, the next greatest frequency of chipped stone tools is seen in the Early Side Notched levels (n=237), followed by the Eva/Morrow Mountain (n=194), Kirk Stemmed (n=153), and finally the Benton period (n=146).

This observation, that the Paleoindian levels produced the most chipped stone tools, is somewhat surprising given prior interpretations of the ephemeral nature of site use during this period, based on analysis of the feature assemblages (Homsey 2004). Homsey notes, however, that this “ephemeral” pattern may be partly attributable to post-depositional processes that affected the integrity of the feature deposits. Nonetheless, given the greater frequency of features, the more substantial nature of those features, and the large quantities of nutshell recovered from later deposits, the frequency of chipped stone tools may not serve as the best indicator of occupation intensity. Instead, the changing nature of the chipped stone tool assemblages may reflect shifts in site use and in the role played by Dust Cave within the larger technological system, particularly as it related to settlement strategies and subsistence pursuits.

If we consider not only the artifacts assigned to a specific zone either during excavation or during subsequent processing, but also those recorded as having been excavated from depths associated with the Paleoindian deposits, a different pattern emerges. I determined ranges of depths for the general “Early,” “Mid,” and “Late” periods of occupation, which correspond to the Paleoindian, Early Archaic, and Middle Archaic periods, respectively. Artifacts were then

assigned to one of these “General Periods.” If we consider this expanded selection of artifacts, the greatest chipped stone tool counts are now seen from the Late Level (Middle Archaic) occupations, followed by the Mid Level (Early Archaic) zones, and the Early Level (Paleoindian) zones. The counts for Late and Mid Levels differ by only 89 artifacts. There is a much greater discrepancy, on the other hand, between the Early and Mid Level counts, with a difference of 264 artifacts. These differences in tool counts may speak more to the general intensity of site use, with more intensive periods of habitation or site use occurring later in the occupation sequence.

TECHNOLOGICAL DIVERSITY

Beyond simply considering the numbers of chipped stone tools represented in each period, it is important to evaluate the *diversity* of artifact types recovered from each zone or period. One of the major issues I am addressing in this dissertation is the nature of toolkits that were utilized at various points in time, and how those toolkits changed through the occupation sequence. Shifts in technology represent changes in the activities that were being carried out, changes in site use, and changes in the adaptive challenges that were faced. Shifts in toolkit diversity provide some insight into these issues. I utilize the term “diversity” to refer to the range of artifact classes represented in any given period.

Examining the range of tool classes present on a site, or within a particular period on a site, is used as a means of interpreting the range of behaviors carried out at that location (Andrefsky 2005: Chapter 8; Binford 1972; Binford and Binford 1966). The range of behaviors can then be used to interpret the function of the site: a raw material extraction locale, a retooling station, a residential base, a hunting camp, etc. The broad range of tools present in the

Paleoindian levels might suggest that Dust Cave served as a residential base, where a wide variety of activities were pursued. Or, the site might have functioned as a retooling locale, where tools used elsewhere in the settlement cycle were discarded as new implements were fashioned. These issues will be considered later in my analysis, with reference to breakage, use, and discard patterns.

The greatest diversity in the technological inventory is seen in the Paleoindian levels. If all Uniface varieties are considered together, and if the multi-purpose Graver/Scraper and Scraper/Perforator are considered within the Unifaces category, then 20 tool classes are represented. If all of these sub-varieties are considered separately, though, 25 classes are represented. Certain categories of tools, while present in the Paleoindian assemblage, were nonetheless represented by very small numbers of specimens. Classes such as the Drills, Early Stage Bifaces, and Humpback Scrapers included 5 or fewer examples from these levels.

Technological diversity continued to be quite high in the Early Side Notched levels, with 18 classes of tools represented (or 22 classes, if all varieties of general Unifaces are considered separately). Several tool classes, despite being present in the Early Side Notched deposits, were represented by no more than 5 specimens. These classes included Early Stage Biface, Mid Stage Biface, Probable Hafted Biface, Drill, End Scraper, Ovoid Scraper, Humpback Scraper, Graver, Blade Scraper, Intentionally Modified Blade, and Unintentionally Modified Blade, as well as the unmodified blades. By the Kirk Stemmed period, at the end of the Early Archaic, diversity had diminished slightly, with only 14 tool classes identified. The categories of Probable Hafted Biface, Humpback Scraper, Perforator, General Uniface, and Blade Scraper were represented by only one or two specimens each. Considering all of the Mid Period specimens together, including those from the mixed Early Side Notched/Kirk Stemmed levels and the General zones, we see a

total of 19 classes of tools represented, with five or fewer specimens representing the Early Stage Biface, Humpback Scraper, Ovoid Scraper, Graver, Perforator, Blade Scraper, Unintentionally Modified Blade, and Unmodified Blade categories.

This degree of diversity remained relatively constant in the Eva/Morrow Mountain phase, with 15 varieties recovered. Underrepresented tool classes included Early Stage Bifaces, Drills, End Scrapers, Side Scrapers, Perforators, General Unifaces, Unintentionally Modified Blades, and Unmodified Blades (BLD), all of which included fewer than 5 specimens. By the latest period of habitation, the Middle Archaic Benton period, only 9 tool classes were represented. The categories of Probable Hafted Biface, Drill, General Uniface, and Unmodified Blade categories were all poorly represented at this time. It is clear that, as a general trend, the diversity of the chipped stone tool inventory decreased fairly consistently through time at Dust Cave, which may suggest a shift in site function. Even when the underrepresented tool categories are taken into account, the greatest technological diversity is seen in the earlier periods, while tool class diversity diminished by the later occupations.

TOOL REPRESENTATION: DEFINING THE TOOLKITS

Certain tool classes are ubiquitous, being present in all zones, while others appear or disappear at various times throughout the use of the site. I do not consider presence/absence of tool classes in the “Zone A” levels, as these appear to represent a palimpsest of unrelated occupations, uses, or site visits during later times, rather than a prolonged, substantial period of site use that can be attributed to a particular cultural manifestation. Those classes that are ubiquitous include the categories of Early Stage Biface, Mid Stage Biface, Trimmed Biface I, Trimmed Biface II, Hafted Biface, Probable Hafted Biface, Bifacial Drill, general Uniface,

Intentionally Modified Flake, and Unintentionally Modified Flake. Unmodified Blades were also recovered in all zones, although their lack of modification means they are not pertinent to this study, except in their capacity to reinforce the importance of this core type during the earlier occupations. While the Hafted and Probable Hafted Bifaces exhibit distinct stylistic changes through time, their functions, as projectile tips or hafted knives, likely remained the same. Almost all of the ubiquitous classes exhibit differences through time in the frequency of specimens and in the proportions of the entire toolkit that those classes represent. In other words, these tool classes become more or less common at different times and represent greater or lesser proportions of the tool inventory for any given period.

The tool classes that are *not* ubiquitous include various Scraper types, Gravers, Perforators, and Blade Tools (Blade Scrapers, Intentionally Modified Blades, Unintentionally Modified Blades). Representation of each of these tool types varies across zones, occasionally in a patterned fashion, and at other times more sporadically.

Below, I address patterns in tool type frequencies and proportions and discuss the composition of toolkits from the various periods of occupation at Dust Cave.

Early Levels: Paleoindian (Zones T, U, S2)

A total of 342 artifacts can be reliably associated with the Paleoindian deposits at Dust Cave. This is the largest number of artifacts associated with a *known* temporal-cultural zone. However, this pattern may in part be a function of the developing understanding of site stratigraphy and occupational sequences that emerged throughout the seasons of excavation. As work proceeded at Dust Cave, the field crew and the geoarchaeologists developed a more refined understanding of site structure and development, enabling more artifacts to be assigned to

designated zones as they were recovered. Artifacts from later in the excavation, and from stratigraphically lower components, were more often assignable to a particular zone than were those recovered early in the excavation history. Table 7.6, below, lists the artifacts present in the Paleoindian inventory, from most to least common.

The Paleoindian assemblage includes a total of 256 flake tools (74.9% of the inventory) and 86 biface tools (25.1% of the inventory). Blade tools are included in the reckoning of flake tool counts, as they represent a specialized class of flake implements.

Several classes of tools are represented almost exclusively in these early deposits. These implements include Side Scrapers, Ovoid Scrapers, Gravers, Blade Scrapers, Intentionally Modified Blades, and Unintentionally Modified Blades. Of particular significance is the fact that all of these classes are restricted primarily to the Paleoindian deposits, and all are specialized, formal flake implements. These types of specialized flake tools do not appear in the later assemblages.

This distribution of artifact types allows the Paleoindian inventory to be characterized as follows: Both ESB and MSB specimens are quite uncommon in the assemblage. While Mid Stage Bifaces are seen in slightly greater frequency than the Early Stage Bifaces, they still are significantly less common than some other artifact classes (e.g., Unintentionally Modified Flakes). The infrequency of these tools in the assemblage may suggest that early stage biface reduction was occurring elsewhere, perhaps nearer to where raw materials were being acquired. Another possibility is that the rarity of these items speaks to an emphasis on raw material economy; in other words, these Stage Bifaces are continuing to be reduced in order to extract the greatest potential utility from them. This latter possibility is less convincing, given the proximity of Dust Cave to sources of the preferred Fort Payne chert.

Table 7.6: Artifact Counts for Paleoindian Zones T, U, and S2. (Data available in Appendix A.)

Type	Count	% of Zone T, U, S2 Assemblage
Early Stage Biface	1	0.29
Mid Stage Biface	10	2.92
Trimmed Biface I	17	4.97
Trimmed Biface II	36	10.53
Hafted Biface	14	4.09
Probable Hafted Biface	8	2.34
Drill	5	1.46
End Scraper	10	2.92
Side Scraper	8	2.34
Ovoid Scraper	8	2.34
Humpback Scraper	1	0.29
Intentionally Modified Flake	41	11.99
Unintentionally Modified Flake	89	26.02
General Uniface	37	10.82
Graver	6	1.75
Blade Scraper	14	4.09
Intentionally Modified Blade	20	5.85
Unintentionally Modified Blade	9	2.63
Unmodified Blade	8	2.34
TOTAL	333	100

Later stage Trimmed Bifaces (I and II) are relatively common in the assemblage but still not nearly as common as they are in later periods. They also tend to represent much lower proportions of the assemblage for the period compared with proportions seen in later periods. So, while quite a number of these tools were recovered, their numbers pale in comparison to other tool classes in the Paleoindian assemblage.

Only 29 Hafted Bifaces/Probable Hafted Bifaces were recovered from the Paleoindian levels. This represents the lowest frequency of Hafted Bifaces, with the exception of the count from the mixed Early Side Notched/Kirk Stemmed zone. The proportion of the assemblage represented by bifaces at this time is also the lowest among all periods at Dust Cave. This pattern may indicate one of several possibilities. First, Hafted Bifaces may not have formed an

especially significant portion of the Paleoindian toolkit or of the various toolkits used at this site. Second, these items may have been heavily curated and simply were not abandoned at the site, but instead were transported and used elsewhere. Third, broken hafted bifaces may have been reworked into other tools. Finally, it is possible that these implements, when exhausted or broken, were discarded elsewhere rather than being returned for retooling.

Of these possibilities, I expect that the first is least likely. Given that deer bones were recovered from the site, albeit in relatively small quantities, projectile tips likely would have formed an important part of the hunting toolkit. The recovery of many broken but unused Hafted Bifaces from this site (see discussion below) suggests that these tools were being produced on-site, possibly for use elsewhere. This possibility is especially likely in the Paleoindian period, when we see evidence for both Hafted Bifaces and End Scrapers but few deer remains on site. It is likely that these tools were being discarded at the site as part of retooling efforts, rather than as part of on-site hunting or butchering activities.

Bifacial Drills (DRL) were recovered in fairly low quantities in the Paleoindian deposits, but their frequency is similar to the numbers of these tools recovered from other periods. Little change is seen in the representation of these tools.

Several varieties of Scrapers were recovered from the Paleoindian deposits, including End Scrapers (ESCR), Side Scrapers (SSCR), Humpback Scrapers (HSCR), and Ovoid Scrapers (OSCR). With the exception of the HSCR category, nearly all scraper types were seen with the greatest frequency in the Paleoindian zones; Humpback Scrapers, on the other hand, are uncommon across all periods. A collection of scrapers produced from blade flakes was also excavated from the Paleoindian levels. The Blade Scrapers included 9 Blade End Scrapers, 3 Blade Side Scrapers, and 2 specimens categorized only as general Blade Scrapers (BSCR).

The frequency of End Scrapers is greatest in the Paleoindian period (10 non-blade specimens, 9 blade specimens), which seems low for representing any significant amount of hide working on the site. Below, I will discuss additional End Scraper specimens that were recovered from the General Early levels, as well as a collection of fragments that likely represent proximal portions of dorsally flaked End Scrapers. These specimens increase the number of Paleoindian End Scrapers from the site greatly. End Scrapers certainly are a common artifact type on other Paleoindian sites in Eastern North America (e.g., Ellis and Deller 1988; Frison 1991; Irwin and Wormington 1970) and in the Tennessee Valley region (Cambron 1955; Hulse and Wright 1989; Walthall 1998). The relative infrequency of End Scrapers in the Paleoindian deposits at Dust Cave may correlate with a paucity of deer remains recovered from the site, although their presence, even in small numbers, suggests that hide working had a place in the Late Paleoindian behavioral repertoire. One possible explanation for this pattern may be that processing and skinning of animal carcasses may have been occurring off-site, or at different points in the settlement-subsistence cycle. Those tools deposited on the site may represent exhausted or otherwise unusable implements that were discarded in anticipation of retooling. I will return to this possibility in my discussion of use life and utility, below. Another possibility is that site use simply was ephemeral enough that substantial deposits did not accrue. Fluvial episodes, which are suggested by geomorphological and feature analyses, may also have removed some of the culture-bearing deposits and their contents (Homsey 2004: 45)

Nearly all of the Side Scrapers from the Dust Cave assemblage were recovered from the Paleoindian zones. In order to interpret the reasons for this pattern it may be important to understand the function of these implements, which will be considered in the following chapter.

The recovery of Ovoid Scrapers was similarly restricted to the Paleoindian levels. Both of these tool types appear to have been used not as hide scrapers but as cutting implements.

Humpback Scrapers seem equally unimportant in all periods, including the Paleoindian, which only produced a single specimen. Functional analysis will help to reveal the purpose of these implements, which may help to explain their scarcity. It is possible that these tools represent a subset of End Scrapers.

All but one of the Gravers was recovered from the Paleoindian zones. This suggests that the activities in which these implements were used were restricted to the earliest time periods or that some other implement later fulfilled the same purpose. Functional analyses, which will be discussed in the following chapter, suggested that the Gravers likely were used for working hard substances such as bone or antler. It is probable that these wear traces are indicative of other technological activities on site, such as the production of spear shafts, tool foreshafts, and handles. Hafted implements certainly existed in later time periods, but their methods of production or the technologies used in their production may have changed.

Unifacial implements, including a variety of sub-types, were recovered in the greatest quantities, by far, from the Paleoindian period. Several uniface were recovered from the subsequent Early Side Notched period, but their numbers decrease nearly to zero in the inventories of later occupations. These items exhibit significantly more intentional modification or more “formality” than the less purposefully altered Intentionally and Unintentionally Modified flakes. Those items classified as general Unifaces tend to exhibit a more distinct working edge shape that shows signs of very deliberate modification.

The frequency of both Intentionally and Unintentionally Modified Flakes is highest in the Paleoindian deposits, although the proportions of the assemblage represented by these tools is

not highest at this time. Regardless, Intentionally Modified Flakes are the most common implements recovered from the Paleoindian period. The frequency of these items in the Paleoindian period may be an indicator of the length or intensity of occupation as well as an indicator of the types of activities being carried out at the site. It is clear that more formal implements were being manufactured here, perhaps for use elsewhere during the remainder of the settlement-subsistence cycle. The frequency of minimally modified flake implements may suggest that activities not related to technological behaviors (i.e., activities we might classify as “domestic”) were also being performed at Dust Cave concurrently with other tasks, such as hunting and tool manufacture. The simple implements could have been fashioned from the detritus left over from tool production and would not have extracted precious utility from the more formal implements that were designed for curation and that were transported and used throughout the settlement round.

With the exception of the unmodified blades (BLD), all other Blade implements were found in the earliest levels, with most from the Paleoindian levels, and a handful from the Early Side Notched period.

Artifacts from General “Early Levels” (Paleoindian)

In addition to the artifacts recovered from the Paleoindian Zones U, T, and S2, a number of artifacts can be assigned to the general Paleoindian levels, those lying at 400+ cm below datum (cmbd). These items are listed in Table 7.7, below.

These additional artifact counts make fairly little difference to the overall Paleoindian tool counts. Some exceptions include the Trimmed Biface I and II categories, which now appear much more prominent in the Paleoindian assemblage. The number of Intentionally Modified

Flake implements also increases, although they still remain less common than the Unintentionally Modified Flakes. Finally, the number of End Scrapers recovered from the Paleoindian deposits nearly doubles.

Table 7.7: Artifact Type Counts from General “Early Levels.” (Data available in Appendix A.)

Type	Count	Type	Count
Mid Stage Biface	3	Humpback Scraper	1
Trimmed Biface I	14	Intentionally Modified flake	14
Trimmed Biface II	14	Intentionally Modified Blade	1
General Uniface	5	Unintentionally Modified Blade	1
End Scraper	9	Blade Scraper	1
Ovoid Scraper	1	TOTAL	64

Mid Levels: Early Archaic (Zones P, Q, R)

A total of 445 artifacts were associated with Early Archaic levels, including 237 from the Early Side Notched levels, 55 from mixed ESN/KS levels, and 153 from the Kirk Stemmed period. Zone Q, which represents the mixed ESN/KS zone, is difficult to analyze because, with the exception of the stylistically distinct Hafted Bifaces, it is impossible to separate the artifacts into their respective temporal categories. The Zone Q materials therefore provide little insight into either distinct period of occupation. In spite of the interpretively problematic nature of these mixed deposits, the Early Side Notched and Kirk Stemmed periods are not substantially different in their artifact inventories. The Zone Q deposits therefore can be used to contribute to overall artifact counts for the Early Archaic.

Zone R: Early Side Notched

The Early Side Notched Zone R deposits produced a total of 237 chipped stone artifacts, including 18 distinct classes (or 22, if all varieties are considered). This level of artifact diversity is second only to that seen in the Paleoindian deposits. Artifact counts for Zone R are presented in Table 7.8.

The Early Side Notched assemblage comprises 136 biface tools (57.4%) and 101 flake tools (42.6%). Comparing these proportions to those from the Paleoindian levels, it is apparent that bifaces were becoming a more significant part of the toolkit.

Unlike in the Paleoindian inventory, no tool classes are represented in the Early Side Notched deposits that are exclusive or nearly exclusive to this period. Tool classes that are present in this zone are either noted in greater frequency in the Paleoindian zones (e.g., MSB, ESCR, OSCR, GRV, UNF, RFL, UFL, and Blade Implements), or continue to be present in later period tool inventories. This pattern may be the result of artifacts moving between strata, or it may speak to the transitional nature of the occupation. The Early Side Notched inventory is no longer fully Paleoindian in character, but retains certain characteristics of the earlier technological assemblage, while simultaneously foreshadowing later Middle Archaic developments. Side Scrapers disappear from the toolkit at this time.

Zone Q: Mixed Early Side Notched/Kirk Stemmed

The mixed Early Side Notched/Kirk Stemmed Zone Q produced a total of 55 chipped stone artifacts, but because they are from a zone of mixed context, the data from this level are not terribly informative regarding period-specific toolkits. I present the data to provide a sense of tool classes and frequencies during the general Early Archaic occupations. Only 10 tool classes

were identified, which are not fully representative of the range of materials seen in either the Early Side Notched or Kirk Stemmed levels. Table 7.9 below presents artifact counts from Zone Q.

The Zone Q assemblage includes 32 biface tools (58.2%) and 23 flake tools (41.8%). The greater proportion of biface tools compared to flake tools is consistent with the Early Side Notched pattern.

Table 7.8: Artifact Counts from Zone R (Early Side Notched. Data available in Appendix A.)

Type	Count	% of Zone R Assemblage
Early Stage Biface	2	0.84
Mid Stage Biface	2	0.84
Trimmed Biface I	36	15.19
Trimmed Biface II	28	11.81
Hafted Biface	62	26.16
Probable Hafted Biface	1	0.42
Drill	5	2.11
End Scraper	2	0.84
Ovoid Scraper	1	0.42
Humpback Scraper	1	0.42
General Uniface	14	5.91
Graver	1	0.42
Intentionally Modified Flake	24	10.13
Unintentionally Modified Flake	52	21.94
Blade Scraper	1	0.42
Intentionally Modified Blade	2	0.84
Unintentionally Modified Blade	1	0.42
Unmodified Blade	2	0.84
TOTAL	237	100

Zone P: Kirk Stemmed

A total of 157 artifacts were recovered from the Kirk Stemmed zone, with 14 tool classes represented. The range of tool classes and frequencies are quite similar to those seen in the Early

Side Notched zone, with a few notable differences. Table 7.10 below lists artifact counts for Zone P.

Table 7.9: Artifact Counts from Zone Q (Mixed ESN/KS; Data available in Appendix A.)

Type	Count	% of Zone Q Assemblage
Mid Stage Biface	2	3.64
Trimmed Biface I	7	12.73
Trimmed Biface II	14	25.45
Hafted Biface	1	1.82
Probable Hafted Biface	7	12.73
Drill	1	1.82
Intentionally Modified Flake	3	5.45
Unintentionally Modified Flake	17	30.91
General Uniface	1	1.82
Blade	2	3.64
TOTAL	55	100

The Zone P inventory comprises 96 biface tools (61.1%) and 61 flake tools (38.9%). The proportions of biface and flake tools are similar to those seen in the Early Side Notched assemblage.

Tool diversity continued to decrease, as the Early Side Notched inventory lost OSCR, GRV, RBLD, and UBLD. All of the blade implements, as well as several specialized unifaces, disappeared by this time, which is not surprising, given their frequent association with Paleoindian and very Early Archaic occupations (Adair 1976; Bradbury and Carr 2012; Broster and Norton 1993; Collins 2002; Hubbert 1989).

Comparing the Early Side Notched and Kirk Stemmed inventories reveals that the four most common artifact types are quite similar between the periods. The frequency of Retouched Flakes diminishes dramatically, as does the frequency of Unifaces. Utilized Flakes top the list, as we begin to see a decrease in the use of intentionally modified and formal flake implements, in

favor of the use of much more expediently produced tools. The increased emphasis on biface tools over flake tools may suggest that these implements began to assume functional roles that used to

Table 7.10: Artifact Counts from Zone P (Kirk Stemmed; Data available in Appendix A.)

Type	Count	% of Zone P Assemblage
Mid Stage Biface	3	1.91
Trimmed Biface I	26	16.56
Trimmed Biface II	26	16.56
Hafted Biface	33	21.02
Probable Hafted Biface	2	1.27
Drill	6	3.82
End Scraper	6	3.82
Humpback Scraper	1	0.64
General Uniface	1	0.64
Perforator	1	0.64
Intentionally Modified Flake	3	1.91
Unintentionally Modified Flake	43	27.39
Blade Scraper	1	0.64
Unmodified Blade	5	3.18
TOTAL	154	100

be fulfilled by more task-specific flake implements. The results of microwear analysis, discussed in the following chapter, should provide some insight into this pattern.

General “Mid Levels” (Early Archaic)

In addition to those artifacts assigned to Zones P, Q, and R, several artifacts were recovered from depths that correspond to the designated Early Archaic Zones. These additional artifacts were recovered from depths between approximately 300 and 400 cmbd, but they were impossible to assign to a specific zone. Artifact counts for these general “Mid Levels” are listed in Table 7.11.

The addition of these artifacts provides a significant boost to the already high frequency of Unintentionally Modified Flakes, raising the count from all specific zones and the general levels to a total of 173. Trimmed Biface I and II counts also increase fairly dramatically (to 111 and 116, respectively), reaffirming the apparent increasing importance of biface implements through the Early Archaic. Intentionally Modified Flake counts increase as well. By incorporating the counts from the general zones, the frequency of Intentionally Modified Flakes nearly doubles, from 30 to 55. With these additional artifacts incorporated into the counts, patterns observed in the specific zones are reemphasized, specifically the increasing importance of biface and expedient flake tools, and the diminishing significance of intentionally modified and more formal flake implements.

Table 7.11: Artifact Counts from General “Mid Levels” (Early Archaic; Data available in Appendix A.)

Type	Count	Type	Count
Mid Stage Biface	3	General Uniface	8
Trimmed Biface I	42	Intentionally Modified Flake	25
Trimmed Biface II	48	Unintentionally Modified Flake	61
Drill	6	Blade Scraper	1
End Scraper	1	Intentionally Modified Blade	2
Ovoid Scraper	1	Unmodified Blade	1
Graver	1	TOTAL	200

Late Levels: Middle Archaic (Zones D, E, J, K, N)

Because four of the zones (E, J, K, N) are associated with a single cultural period (Eva/Morrow Mountain), I divided these zones into “Late A” and “Late B” levels. Late A represents the Eva/Morrow Mountain levels (Zones E, J, K, and N), while Late B (Zone D only) represents the Seven Mile Island/Benton phase. A total of 389 tools were recovered from the

Middle Archaic zones: 194 from the Eva/Morrow Mountain phase, and 146 from the Seven Mile Island component.

Late A: Eva/Morrow Mountain (Zones E, J, K, and N)

The Eva/Morrow Mountain zones produced a total of 194 artifacts, including 15 tool classes (or 16, if all varieties are considered). The range of artifact types represented is quite similar to the range observed in the Kirk Stemmed inventory, with only some minor differences noted. Tool proportions also differ somewhat. Artifact counts for the Late A levels combined are presented in Table 7.12.

The Eva/Morrow Mountain assemblage includes 151 biface tools (77.8%) and 43 flake tools (22.2%). These proportions show an even greater increase in the emphasis on bifaces, specifically HAB/PHB, TBI and TBII, with comparatively few flake tools represented. The Trimmed Biface II category increases in prominence over Unintentionally Modified Flakes as the most common chipped stone tool class recovered. The frequency and proportion of Unintentionally Modified Flakes drop significantly. Early Stage Bifaces reappear with the greatest frequency seen in any zone, although only four specimens were recovered. An increase is also noted in the number of Mid Stage bifaces, with their frequency nearing the number of specimens recovered in the Paleoindian levels. The number of Hafted Bifaces increases dramatically, and the number of Probable Hafted Bifaces also rises. The frequency of bifacial Drills remains nearly unchanged from the previous period.

Among the flake tools, a drop is seen in the frequency of End Scrapers, while Humpback Scrapers disappear entirely. The number of Intentionally Modified Flakes increases, but their frequency continues to be lower than that recorded from the earlier periods. The frequency and

proportion of Unintentionally Modified Flakes decreases fairly notably. Blade tools continue to be absent or very uncommon, with only one Unintentionally Modified Blade and three Unmodified Blades recovered.

Table 7.12: Artifact Counts from Middle Archaic Zones E, J, K, and N. (Data available in Appendix A.)

Type	Count	% of Zone E, J, K, and N Assemblage
Early Stage Biface	4	2.06
Mid Stage Biface	8	4.12
Trimmed Biface I	27	13.91
Trimmed Biface II	55	28.35
Hafted Biface	42	21.65
Probable Hafted Biface	11	5.67
Drill	4	2.06
End Scraper	3	1.55
Side Scraper	1	0.52
Perforator	2	1.03
General Uniface	2	1.03
Intentionally Modified Flake	8	4.12
Unintentionally Modified Flake	23	11.86
Intentionally Modified Blade	1	0.52
Unmodified Blade	3	1.55
TOTAL	194	100

General “Late A” Levels (Eva/Morrow Mountain)

Several artifacts were recovered from depths associated with Eva/Morrow Mountain levels that were located between approximately 200 and 300 cmbd. Table 7.13 lists the artifact counts from these general “Late A” levels.

Incorporating these artifacts into the Eva/Morrow Mountain counts significantly increases the number of Unintentionally Modified Flakes, for a total of 115. There clearly was great emphasis during this period on these expedient implements. A great increase is also noted

in the numbers of Trimmed Biface I (n=82) and Trimmed Biface II (n=111) categories, which again confirms the emphasis on biface tool use.

Table 7.13: Artifact Counts from “Late A Levels.” (Data available in Appendix A.)

Type	Count	Type	Count
Mid Stage Biface	3	General Uniface	3
Trimmed Biface I	55	Intentionally Modified Flake	12
Trimmed Biface II	56	Unintentionally Modified Flake	92
Drill	8	Intentionally Modified Blade	4
End Scraper	1	Unmodified Blade	2
Perforator	1	TOTAL	237

Late B: Benton (Zone D)

The Middle Archaic Benton period deposits produced a total of 146 artifacts. The inventory appears quite different in some ways from the earlier Eva/Morrow Mountain zones. Only 9 total tool classes are represented, and several classes that were present in the Eva/Morrow Mountain assemblage disappear in the Benton deposits. Frequencies and proportions of certain tool classes are also very different. The Zone D artifact counts are listed in Table 7.14, below.

The Zone D assemblage includes 126 biface tools (86.3%) and only 20 flake tools (13.7%). This zone exhibits the greatest emphasis on biface technology, particularly Hafted Bifaces, Probable Hafted Bifaces, and Stage Bifaces. Only 13.7% of assemblage is composed of flake tools, with no specialized flake implements represented. Instead, the flake tool inventory includes only expedient implements and modified blades.

The character of the artifact profile from this zone is very different from that seen in any other zone. The frequency and proportion of Hafted Bifaces far outnumber all other classes in the Benton period, as well as the frequencies or proportions of Hafted Bifaces from any other period.

Hafted Bifaces make up almost 50% of the Benton component, and their frequency represents almost 30% of all Hafted Bifaces that were assignable to a particular cultural zone.

Table 7.14: Artifact Counts from Zone D. (Data available in Appendix A.)

Type	Count	% of Zone D Assemblage
Early Stage Biface	6	4.11
Mid Stage Biface	5	3.42
Trimmed Biface I	13	8.90
Trimmed Biface II	29	19.86
Hafted Biface	71	48.63
Probable Hafted Biface	2	1.37
Intentionally Modified Flake	16	10.96
Unintentionally Modified Flake	2	1.37
Unmodified Blade	2	1.37
TOTAL	164	100

Other differences exist in tool class representation as well. Compared to the Eva/Morrow Mountain assemblage, the Benton period produced fewer Trimmed Biface I and II specimens. Drills, End Scrapers, and Side Scrapers all disappear from the assemblage, and both Intentionally and Unintentionally Modified Flakes are much scarcer than in previous levels.

The great emphasis on Hafted and Stage Bifaces, and the comparatively minimal use of flake tools suggests a major technological change at this time. The question remains, though, of whether this shift represents a change in technological organization, subsistence strategies, site use, or a combination of these factors.

General “Late B” Levels (Benton)

In addition to the artifacts that were attributed to Zone D, several artifacts were recovered from depths associated with the Benton period, between approximately 145 and 200 cmbd.

These artifact counts from the Late B levels are presented in Table 7.15.

With these additional artifacts, we see a dramatic increase in number of Unintentionally Modified Flakes, for a total of 88. The number of Trimmed Biface I (total of n=43) and Trimmed Biface II (total of n=83) specimens also increases. A slight increase is also seen in number of Intentionally Modified Flakes. The total remains relatively small (n=18), though, especially when compared to the number of Unintentionally Modified Flakes. The importance of stage bifaces and expedient flake tools continues to be apparent, suggesting a definite shift in technological strategies from the Paleoindian and earliest Early Archaic levels in which specialized flake implements were significantly more dominant in the assemblages.

Table 7.15: Artifact Counts from “Late B Levels.” (Data available in Appendix A.)

Type	Count	Type	Count
Early Stage Biface	3	Drill	1
Mid Stage Biface	8	General Uniface	5
Trimmed Biface I	30	Intentionally Modified Flake	16
Trimmed Biface II	54	Unintentionally Modified Flake	72
TOTAL		189	

Summary: Toolkits and Changes over Time

The preceding discussion of tool class representation highlights several trends through time in the chipped stone tool assemblages from Dust Cave.

First, certain tool classes are ubiquitous in the toolkits across various zones, while others are more or less common at various points throughout the occupation history. Those classes that are ubiquitous include Late Stage Bifaces (Trimmed Biface I and II), Hafted Bifaces, Probable Hafted Bifaces, Intentionally Modified Flakes, Unintentionally Modified Flakes, and

Unmodified Blades. Note that these classes can be viewed as generalized tools that likely were multi-purpose or multi-functional.

The tool classes that appear and disappear at various points in the occupation sequence are those that are more morphologically and functionally specific. In the Late Paleoindian and Early Side Notched levels we see a greater emphasis on more formal unifacial implements, especially scrapers, and on blade tools. With the exception of the items identified as “unmodified blades,” blade tools ceased to be recovered after the Early Side Notched (ESN) period, and these ESN examples were rare compared to their frequency in the Paleoindian zones. Hafted Bifaces, Probable Hafted Bifaces, and Stage Bifaces are much more common in later periods, with Hafted Bifaces and Trimmed Biface II specimens topping the artifact inventories in the Middle Archaic Late A and Late B levels.

Unintentionally Modified Flakes are very common in the Paleoindian (PI) and Early Archaic (EA) zones, and become less frequent through time. Similarly, Intentionally Modified Flakes are significantly more common in the earlier zones (PI and EA), and are very uncommon in the Middle Archaic (MA). It is notable that the Intentionally Modified Flake tools decrease in frequency at the same time as the Unifaces, suggesting that all purposefully modified flake implements became less common around the same time. I was not surprised to see large numbers of both Intentionally and Unintentionally Modified Flake tools at the site. With easy access to raw materials, it is not surprising that toolmakers seemed to favor the use of simple tools to accomplish tasks that they undertook while stationed at the site. Rather than expending time and energy on producing more formal implements, which are labor-intensive to create, a simple flake implement, with its sharp edge, would have been appropriate for the completion of many tasks. It is intriguing, though, that the greatest numbers of these simplest tools are seen in the Paleoindian

levels. Based on subsistence patterns and the less substantial nature of the features seen in the earliest levels, it has been suggested that the Paleoindian occupation at Dust Cave was a relatively ephemeral one, perhaps representing a brief occupation episode while hunters exploited the migratory waterfowl that were drawn to sinkholes in the uplands (Homsey 2004: 45; Walker 1998). The large numbers of expedient flake tools are at odds with this interpretation, suggesting that site use and technological needs/organizational strategies may be different from what we expected.

While differences exist in the tool inventories of all periods, the Paleoindian toolkit is perhaps most distinctive, with the Early Side Notched as a close second. The Paleoindian assemblage is much more diverse than assemblages recovered from later periods, and it contains several tool types that either were not recovered at all in later assemblages, or that were recovered only in low frequencies. Particularly notable is the emphasis on specialized unifaces and blade tools, all of which decrease in representation at the end of the Paleoindian period or in the Early Side Notched at the latest.

At the other end of the occupation span represented at Dust Cave, the Seven Mile Island deposits (Zone D) are also distinctive, having very low artifact diversity compared to any of the earlier periods. Nearly 50% of the chipped stone tool assemblage recovered from Zone D consisted of Hafted Bifaces, a pattern that is unprecedented in earlier periods.

In general, greater tool diversity is seen in the earlier occupation periods, as many more tool classes are represented in the Paleoindian and Early Archaic deposits than in the Middle Archaic levels. This pattern suggests a shift in technological organization, subsistence practices, and/or site use. These possibilities will be considered and analyzed in greater detail in the remainder of this chapter.

To begin to comprehend the meaning of these shifts, it is helpful to consider other features of the technology, beyond simply changes in the artifact inventory. In the following section, I discuss the design and manufacture of tools at various points throughout the occupation sequence. The design process begins at the level of raw material selection and continues through the processes of core production, tool manufacture, and tool use. Aspects of tool design may also influence the decisions of toolmakers and tool users regarding when to discard an implement. I discuss each of these categories below, beginning at the level of raw material selection.

DESIGN CONSIDERATIONS: RAW MATERIAL SELECTION

Raw material selection exerts a significant influence on technological design choices and is influenced by a complex array of factors that range from availability and accessibility of sources within the environment, to the functional needs of tool users. The availability of suitable raw materials within the environment imposes the most fundamental constraints on toolmakers and is influenced by the nature of the local geology, the geographical or seasonal accessibility of those raw materials, and the nature of human settlement rounds, which can result in disparities between the locations of material sources and locations of tool use (Andrefsky 1994a, 1994b; Bamforth 1986).

Even in regions that contain appropriate materials for chipped stone tool production, and where those materials are easily accessible, certain material types may be more or less suitable for the production of particular tool types. The package sizes in which raw materials are available limit the types and attributes of tools that can be produced. For example, small pebbles of chert cannot be transformed into large blades or large bifaces. Under such size constraints, the technology may appear more diminutive, or may require the use of particular reduction strategies

to maximize the amount of usable material that can be extracted from such units (e.g., bipolar reduction; see Andrefsky 1994b). In contrast, material that is available in larger packages (e.g., large nodules or bedded deposits) is more suitable for the production of larger-sized tools.

The tractability of available raw material types may also be of concern to toolmakers. If toolmakers were intent on the production of implements that could be reworked and resharpened with ease, the use of raw materials that could be manipulated easily and flaked predictably may have been a deciding factor in raw material selection (e.g., Goodyear 1979). In choosing raw materials, then, the toolmaker must anticipate the life history of the implements being produced. Similarly, the toolmaker must consider the activities in which tools will be used, as the types of stresses to which a particular class of implements will be subjected may govern the required strength of the material that is chosen. For example, fine-grained chert that flakes easily might not be an ideal choice for the production of heavy woodworking implements such as axes.

Raw material availability and accessibility likely imposed few limits on the chipped stone technology at Dust Cave, as the site lies in a material-rich portion of northeastern Alabama. Initial examination of the collections from Dust Cave, by Meeks (1994), revealed a strong emphasis on the use of locally available Fort Payne chert, most notably of the blue-grey variant. A survey of the locally available lithic sources within the Pickwick Basin by Johnson and Meeks (1994) revealed that Fort Payne chert is widely available in the region as both primary outcrops along the Tennessee River bluff line and as secondary deposits in the gravel bars within the Tennessee River. Despite its ubiquity in the study area, the available Fort Payne sources vary widely in both quality and appearance. Johnson and Meeks (1994: 67) note that, "In general, primary context Fort Payne possesses a dull luster, coarse texture and low tractability, whereas secondary deposit cherts exhibit a high luster, medium to fine texture, and a high degree of

tractability.” In other words, the materials recovered from secondary cobble deposits are of overall higher quality than the Fort Payne extracted from primary bedded deposits.

Johnson and Meeks (1994) performed macroscopic visual inspection of the materials recovered during their survey work, noting the color, luster, texture, inclusions, and tractability of the specimens, and compared these samples to a selection of diagnostic hafted bifaces recovered from the site. While blue-grey Fort Payne chert appears to have been the preferred raw material type, the authors identified some additional raw material sources, including other Fort Payne variants, Tuscaloosa Gravel, Camden, and Bangor cherts. They noted that a) Fort Payne chert appears to have been the preferred raw material throughout the use of Dust Cave, and b) the majority of this Fort Payne chert was procured from secondary contexts (Johnson and Meeks 1994: 20).

This pattern was confirmed in Meeks’ (1994) preliminary study of a sample of artifacts from Test Unit F, located within the cave. Most tools in the sample were produced from Fort Payne chert, although certain specimens were manufactured from other locally available materials, including Tuscaloosa Gravel and Camden chert. In addition to these local cherts, Meeks (1994) identified specimens made from non-local Bangor chert, which outcrops 40-50 km upriver from Dust Cave, but that may have occurred in local river deposits in the area of the cave. Meeks (1994: 81) writes that this pattern of raw material use “suggests very localized resource procurement throughout the long history of occupation at Dust Cave.” This same pattern of local, spatially restricted resource use was apparent in Hollenbach’s (2005) study of subsistence remains from Dust Cave as well. This pattern stands in stark contrast to the typical interpretation of Paleoindian and Early Archaic foragers as being highly mobile (e.g., Daniel

1998: 1-10; Kelly and Todd 1988) and may be related to the rich and varied nature of resources in the middle Tennessee River valley.

My own study of raw material use at Dust Cave seems to confirm the patterns noted by Meeks (1994). Of the 919 specimens for which material types were identified, 898 (97.7%) were produced from Fort Payne variants. Only a small number of specimens were produced from non-Fort Payne materials, including: Tuscaloosa Gravel (n=6), Camden chert (n=6), Bangor chert (n=4), Agate and Chalcedony (n=3), and Burlington chert (n=2). A few other materials were noted but not identified, including several dark grey, black, and tan materials that may represent the range of variation seen in Fort Payne.

Mississippian age Fort Payne chert is found in limestone deposits across much of Lauderdale County (45% surface coverage). The Fort Payne formation is variable in texture, color, and inclusions, with “abundant nodules, lenses and beds of light to dark grey chert” (USGS 2012) found within the limestone deposits. In short, it is abundant and variable within the study location.

Tuscaloosa Gravel and Camden cherts are also locally available in the vicinity of Dust Cave. The Cretaceous period Tuscaloosa Formation comprises massive sand and gravel beds, the lower part of which “is predominantly a gravelly sand consisting chiefly of chert and quartz pebbles” (USGS 2012). This geologic unit is noted across Lauderdale County in northwestern Alabama, with approximately 11% surface coverage.

Camden chert is found within the Devonian age Camden Formation deposits. This chert, which is found in small quantities (<0.1% surface coverage) in Lauderdale County, is described as being light grey in color and Novaculitic in character (USGS 2012).

Bangor, which is the most common non-local raw material noted in the sample, is known from much of north-central Alabama, upriver of the Dust Cave environs. This Mississippian age chert is very similar in appearance to blue-grey Fort Payne chert, being distinguishable only by the presence of a thin layer of white or tan material below the cortex (Davis 2008: 38).

Chalcedony and agate are found in various locations in north-central and central Alabama. The most nearby sources are noted in Blount, Jackson, Jefferson, Madison, and Tuscaloosa Counties (Cook and Smith 1982; Dean 1995). The small number of specimens produced on these materials, in conjunction with lithic and subsistence data that indicate otherwise very local resource use patterns, suggests that outcrops were not exploited directly by toolmakers from Dust Cave. Their presence in the sample may, instead, represent exchanges with neighboring bands. Overall, though, a strong emphasis on local raw material procurement is evident in the Dust Cave assemblage.

Raw Material Use by Period

While Fort Payne chert, and especially its blue-grey variant, is the most common raw material type seen in the Dust Cave lithic assemblage, other raw materials were used occasionally in the production of chipped stone tools at the site. Some of these materials were available in the immediate vicinity of the cave, while others were procured, either directly or indirectly, from sources at greater distances from the site.

In the study of North American prehistoric archaeology in general, and Eastern North American prehistoric archaeology more particularly, archaeologists have tended to view Paleoindian and Early Archaic populations as more mobile than later Middle Archaic groups, moving frequently throughout the year in order to exploit seasonally available resources.

Following from this assumption, we might expect to see greater exploitation of non-local lithic raw materials during earlier periods, and the use of more locally available materials in later periods, simply because of greater ease of access to these non-local sources by more nomadic populations.

At Dust Cave, subsistence and feature data have suggested relatively ephemeral occupations during the Paleoindian period, with longer periods of occupation and more intensive use of the site possible by even the initial part of the Archaic period (Sherwood et al. 2004: 547). Ephemeral occupations and apparent highly seasonal use of the site during the Paleoindian period suggest that these populations likely were quite mobile. In spite of this presumed high level of nomadism, the raw material profile shows an almost exclusive reliance on locally available materials. The few non-local stone types that entered the assemblage may have been acquired throughout the settlement-subsistence cycle, either through direct or indirect procurement, or may represent the movement of individuals, perhaps through mate exchanges between bands in the region. Many of these chert types are available in the bed load of the Tennessee River, so their use may in fact represent local procurement of these materials.

The data from the artifact classes examined here confirm an almost exclusive reliance on Fort Payne chert in all time periods at Dust Cave (Table 7.16). While several varieties of Fort Payne were represented, the Blue-Grey variant was by far the most commonly used. In the Paleoindian period, when we might expect to see the greatest use of exotic materials in light of the presumed higher degree of residential mobility exhibited by these earlier populations, only 1% (n=3) of the identified materials were other than some variant of Fort Payne. In the earliest part of the Early Archaic, another period in which we might expect the use of more exotic materials, only 2% (n=5) of the identified sources were other than a Fort Payne Variant. The

same pattern holds true in the later Early Archaic (3%, n=4), the earliest Middle Archaic levels (2%, n=3), and the later Middle Archaic (4%, n=5). By proportion, then, the greatest use of non-Fort Payne chert is seen in the latest period, but the difference (1% vs. 4%) is negligible and may be a function of sample size or error in material identification.

As discussed above, variants of Fort Payne chert are available across a wide swath of northwestern Alabama. It is possible, therefore, that toolmakers procured their materials during their travels at locations removed from Dust Cave. Another possibility, and one that might explain the low frequencies of non-local raw materials in the assemblage, is that the presence of these materials represents exchanges (either of stone or of people) with groups living elsewhere in the region. However, these apparent non-local specimens might also have been available in the gravel load of the nearby river channel. It is difficult, using only visual identification methods, to separate out those specimens produced from Fort Payne that was available in the immediate environs of the cave, from those produced from Fort Payne that was procured elsewhere. The data demonstrate, though, that tool manufacturers were making significant use of this high-quality and easily procured raw material at all times throughout the cave's occupation sequence.

In light of this overwhelming emphasis on Fort Payne chert, a consideration of differences in the use of material types for the production of various artifact classes is rendered uninformative, as the sample size of non-Fort Payne cherts is too small to allow any sort of reasonable conclusions to be drawn.

DESIGN CONSIDERATIONS: CORE PRODUCTION

Following raw material selection and acquisition, toolmakers proceed to reduce raw material packages into suitable core types. In this section, I consider the core types used in the

production of those tool classes that retained evidence of the original flake or blank characteristics. Because they experience significant amounts of modification, bifacial implements less often exhibit traces of the original blanks from which they were produced. Flake tools, on the other hand, often are less intensively modified and thus retain traces from core preparation or blank production that can provide insight into the nature of core technology. For this reason, I do not consider the stage bifaces (ESB, MSB, TBI, and TBII) or the bifacial Drills (DRL) in the following discussion. I focus instead on the flake implements, including the Scrapers, Unifaces, Intentionally and Unintentionally Modified Flakes, and Blade tools.

Table 7.16: Chert Types by Period. (Primary data available in Appendix A.)

General Zone	Zone	BGFP	FP	BANG	CAM	TUSC	PICK	CHAL	AGA	BUFF	BURL	TOTAL (specific Zone)	TOTAL (General Zone)
PI	U	60 (+12)	10 (+1)		1			1				72	260
	T	159	15							1		175	
EA (early)	R	128 (+49)	12 (+15)			1	1				2	144	251
	Q	39	2	1					1			43	
EA (late)	P	89 (+22)	14 (+1)	2			1	1				107	130
MA (early)	N	14 (+12)	1 (+3)	1		1						17	155
	K	36	6									42	
	J	34	2									36	
	E	36	8						1			45	
MA (late)	D	61 (+40)	10 (+7)		3	2						76	123

Periods: PI = Paleoindian; EA = Early Archaic; MA = Middle Archaic.

Cherts: BGFP (Blue-Grey Fort Payne); FP (all other Fort Payne variants); BANG (Bangor); CAM (Camden); TUSC (Tuscaloosa Gravels); PICK (Pickwick); CHAL (Chalcedony); AGA (Agate); BUFF (Buffalo River); BURL (Burlington); OTH (other)

Among several artifact classes, especially the non-diagnostic implements such as the intentionally and unintentionally modified flake tools, it was often impossible to assign specimens to particular zones. This contributed, initially, to very low counts in the later periods, when use of non-formal implements appears to have increased. To allow more sound conclusions to be drawn regarding the nature of core production, I refer instead to general periods that include materials condensed from the specific zones and their associated general depths. These general periods include Early (Paleoindian Zones U, T, and S2), Middle (Early Archaic Zones R, Q, and P), Late A (Middle Archaic Zones N, K, J, and E), and Late B (Middle Archaic Zone D) periods. Artifacts were assigned to one of these general zones based on the depths at which they were recovered, and the correlation between depths below datum and assigned zone designations. Depths for these various zones are as follows: Early: >400 cmbd; Middle: 300-400 cmbd; Late A: 200-300 cmbd; Late B: 145-200 cmbd. Tools recovered from depths shallower than 145 cmbd represented the latest mixed deposits and are not considered here.

Core types were identified on the basis of flake characteristics that were retained on the finished pieces. Characteristics of the platform, as well as the dorsal and ventral surfaces, were used to determine core types. A full discussion of these characteristics can be found in Chapter 5.

Table 7.17, which groups the data into broader temporal categories, reveals two strong trends. First, we see a dramatic decrease in the use of blades over time, with the greatest representation being in the Early (Paleoindian) and Middle (Early Archaic) periods. Second, we see a dramatic increase in the use of biface-derived flakes over time. This increase in the use of biface flakes likely correlates with the increased emphasis on bifacial implements in later periods and stands in contrast to the apparent preference for blade use in the earliest levels. Toolmakers likely would have found it simple enough to select appropriate flakes for flake tool production

during the reduction of bifacial cores or implements. It should be noted that some of those specimens identified as “blades” in the later periods may, in fact, be blade-like flakes and could represent biface-derived flakes that mimic the appearance of true blades. Without retention of platform characteristics, it can be difficult to separate true blades from blade-like flakes.

Other flake types show less apparent fluctuations in popularity over time, and their presence in the assemblage may simply reflect the use of fortuitously-produced and appropriately sized or shaped flakes during other core reduction trajectories. For example, the selection of cobble-derived flakes may indicate the use of blanks that were removed during the initial stages of reducing nodular pieces of raw material into a variety of core types. Similarly, the “blocky” blanks may suggest preparation of other core types through the shaping of an angular piece of material into the desired core shape. Amorphous or multidirectional blanks likely represent flakes produced during the preparation and reduction of a variety of core types, or could represent the production of flakes, as needed, with little or no thought given to core preparation.

Table 7.17: Blank Types by General Period. (Data available in Appendix A.)

General Period	Biface	Bipolar	Blade	Blade-Like	Blocky	Cobble	Amorphous	Total
Early	15 (10.6%)	1 (0.7%)	67 (47.5%)	4 (2.8%)	17 (12.1%)	9 (6.4%)	28 (19.9%)	141
Middle	21 (24.4%)	0 (0.0%)		4 (4.7%)	19 (22.1%)	9 (10.5%)	33 (38.4%)	86
Late A	23 (32.9%)	0 (0.0%)	2 (2.9%)	1 (1.4%)	15 (21.4%)	4 (5.7%)	25 (35.7%)	70
Late B	21 (31.3%)	0 (0.0%)	5 (7.5%)	1 (1.5%)	23 (34.3%)	3 (4.5%)	14 (20.9%)	67

We may seek to explain the choice of core type by reference to a number of technological concerns, including the nature and prevalence of raw materials, the relative emphasis on expediency or curation, the particular functional requirements of the finished implement, etc.

The first of these factors, the nature and availability of raw materials, exerts a particularly strong influence on the selection of core type. For example, if materials are available only in small package sizes, then the nature of the raw materials might dictate the use of a core technology that emphasizes material conservation (e.g., bipolar reduction). In such a case, raw material size will influence both the appearance of the core technology and the appearance of the resulting toolkit (e.g., diminutive tools, presence/absence of particular tool types, and a particular degree of emphasis on curation).

Without constraints on raw material package size or availability, more flexibility in production is possible. At Dust Cave, large blades were produced during the Paleoindian period, a technological feat that could not have been accomplished without the availability of large-sized pieces of stone. Similarly, the production of large bifaces was made possible by the availability of chert in large packages. The emphasis on simple flake tools, seen in the later periods of occupation, may also be a function of raw material abundance in the region. The richness of raw material sources around Dust Cave may have encouraged the use of a less structured core technology in response to a lack of concern for conservation or for maximizing efficiency in production. In other words, when raw material is so easily available, there is less need to focus on producing tools from highly efficient cores. The use of an amorphous core production technique would, therefore, have sufficed for producing flakes from which suitable blanks could be selected. I discuss and evaluate these possibilities in the following section.

DESIGN CONSIDERATIONS: TOOL PRODUCTION

Following raw material selection, core preparation, and blank production, the toolmaker may then elect to modify the chosen blanks to produce desired tool forms. Depending on the

particular core production techniques employed, the abundance of stone raw materials, and the morphological or functional requirements of a class of tools, different amounts of effort may have been invested in tool production. Determining where in the production sequence effort was being invested, and how much effort was being invested, is significant to the analysis of design considerations and how manufacturing choices reflect reactions to adaptive challenges.

One means of determining where energy is being spent in technological production is to consider the core type from which blanks were derived and the degree of post-detachment modification applied to those blanks. Perlès (1992) has argued that lithic analysts may understand stone tool production as a basic dichotomy between hasty, rapid production, with little investment of time or energy, and careful, deliberate production, which requires a greater investment in manufacture. Hasty production generally involves the creation of minimally modified implements, often with little care given to producing formal cores or standardized forms, and may simply involve the expedient selection and use of blanks with appropriate but fortuitously-produced characteristics. Deliberate, careful production, on the other hand, may be achieved either at the stage of blank production, or during subsequent tool modification. Cores may be set up in such a way as to allow the production of blanks with predictable, desired sizes and shapes. Tools then require comparatively little post-detachment modification in order for desired forms to be achieved.

We may think about this dichotomy, and its adaptive ramifications, from a perspective analogous to the concerns of behavioral ecology, which considers how particular behavioral options arise in order to negotiate the challenges posed by the environmental context. When considering stone tool production from this perspective, we may ask under what conditions either production option provides the greatest return on investment. Why would toolmakers choose to

invest great amounts of time and energy in the production of implements when expediently produced flakes, with razor-sharp margins, are appropriate for carrying out many tasks? Where in the production sequence is it best to invest time and energy so that the technology does not overshadow other needs but, instead, facilitates the accomplishment of other goals? Approaching this question of investment in production, either at the stage of core preparation or post-detachment modification, can provide insight regarding hunter-gatherer adaptive concerns, in particular the amount of time available for the performance of tasks beyond those related directly to tool production. We may consider this issue by asking whether toolmakers were investing effort in tool production in anticipation of future use, or as needs arose. Time constraints on other activities, such as hunting, gathering, and processing tasks, may govern whether toolmakers produce well-designed standardized implements in advance of use or whether they turn to quickly manufactured expedient tools with short life spans.

The decision to produce curated or expedient technologies is guided, to a large extent, by the impact that the availability and accessibility of raw materials has on the amount of time available to perform other activities (Odell 1996, Torrence 1983). Disparities in the locations of raw material sources and the locations of tool use influence the timing of certain technological decisions, including when in the subsistence round raw materials should be procured and how to ensure that raw materials are available at locales farther from the source (Binford 1977, Odell 1996). This may involve the production of tools that will remain usable and that have the potential for reuse and recycling while away from the raw material source. These sorts of disparities essentially create raw material scarcity at certain times of the year. Under such conditions toolmakers might opt to produce implements that could be resharpened and reused repeatedly, in order to conserve materials. I have already discussed raw material availability at

Dust Cave and have suggested that there seem to have been few constraints on availability and package size. Tool producers were making nearly exclusive use of Blue-Grey Fort Payne chert, which outcrops abundantly in the immediate environment as well as in the surrounding region, being available as large cobbles or in bedded deposits along the Tennessee River. In addition to Fort Payne chert, other materials also outcrop in the region in sufficient quantities that toolmakers would have had access to suitable raw materials even when away from Dust Cave (e.g., Tuscaloosa Gravel). Some of these other materials are of lower quality, though, and are available in smaller package sizes than the large, high-quality Fort Payne nodules and beds around Dust Cave. Raw material quality was also of little concern, as much Fort Payne chert, especially of the Blue-Grey variant, is of high quality and could therefore have been shaped and reshaped easily.

Intended tool function also governs a variety of manufacturing choices, such as: the selection of raw materials best suited to the manufacture of tools for specific functions; the required strength of the implement or its components; and the need for hafting elements that provide greater leverage during use, that allow easy replacement of broken parts, or that reduce hand stress during use. These requirements affect raw material selection but also affect other elements of tool production, including how much effort is invested in the modification of blanks after their removal from the parent piece.

Time stress in the performance of tasks in which these implements are used may also govern the decision to produce a more highly curated and standardized technology rather than making use of an expedient toolkit or a less standardized set of implements (Torrence 1983). The production of multiple, standardized and, therefore, easily replaced tools, may be deemed advantageous. Tools with standardized haft elements could be prepared in advance for easy

replacement during intensive periods of use to prevent the need for pausing mid-task to rework a broken implement. Alternatively, multiple tools already attached to foreshafts could be transported to the location of use, and the entire tool and foreshaft portion could be replaced.

To assess the degree of effort expended in the production of tools, it is useful to consider the degree of standardization of both core preparation/blank production and finished tool forms. Standardization, in this context, refers either to the idea that cores were prepared in such a way as to produce consistent blanks (i.e., consistency in size, shape, thickness, etc.) or that tools were modified, after detachment of the blank, so that they conformed to a strict set of requirements as defined by a preconceived mental template (e.g., dimensions of the haft element, edge angles, etc.).

Various researchers have suggested that earlier toolmakers, especially Paleoindians and some Early Archaic populations, emphasized standardization of *cores* as an initial step in the lithic production sequence. Producing standardized cores, such as highly prepared blade cores, allows the removal of blanks with predictable characteristics (see Knudson 1973; Lothrop 1989; MacDonald 1968; Payne 1987; Wilmsen 1970). In the production of standardized cores, toolmakers guide core preparation toward the removal of predictable blanks that conformed to desired standards, directing the technological process so that functionally desirable blanks would be produced from the outset. According to Wilmsen (1970), such blanks were produced so as to require little post-detachment modification in the production of desired tool forms.

Core production in the Middle Archaic and later periods, on the other hand, has been regarded as much less standardized. Researchers who study the Archaic period have often suggested a greater reliance on expedient production methods and more fortuitous blank selection (e.g., Anderson 2005: 35; Wright 1995: 65). More haphazard core production should be

apparent in the archaeological record through an emphasis on less formalized cores, resulting in the production of less standardized blanks, or through the use of more expedient implements.

As discussed above, such a shift, from the use of blade tools in the Paleoindian period to the use of bifaces and more expedient flake tools in the Archaic period, is apparent in the Dust Cave inventory. This appears to support the notion of declining formality in core preparation through time. Technological strategies tend to change when they are no longer deemed to be useful in a particular context (Perlès 1992). It is natural to ask, then, what sorts of changes occurred through time to induce the technological shifts seen at Dust Cave.

Before considering the particular patterns noted at Dust Cave, it is useful to discuss, in more general terms, what might cause toolmakers to focus on standardized vs. unstandardized (or formal vs. informal) modes of core and tool production. Flakes can be altered quite easily through the application of secondary modification, so why would toolmakers opt to invest time and effort in the production of standardized cores? Several researchers have tackled this question, and their answers have included the need to conserve raw material (Johnson 1987; Jeske 1989), the effects of time stress (Torrence 1983), the influence of techno-functional constraints (Perlès 1992), the requirements for tool maintenance (Parry and Kelly 1987), and the requirements for transportability among mobile populations (Bamforth 2002).

Johnson (1987) and Jeske (1989: 36) have both proposed that standardized core production might serve as a means of conserving raw materials by reducing the amount of waste created during the early stages of lithic manufacture compared to that produced through the use of amorphous cores. This explanation does not provide a convincing interpretation of the Dust Cave data because, as discussed above, inhabitants of the cave were living in a raw material-rich region. Conservation of materials in production likely would not have been a prime concern.

This explanation suffers from another flaw, namely that flakes from amorphous core reduction could still have been used as simple, expedient tools. These less formal core types produce blanks with a wide range of edge forms and edge angles that are usable in a variety of tasks. Parry and Kelly (1987: 287) cite ethnographic examples in which no distinction is drawn between “waste” and “tools,” as all flakes are potentially useful items. If raw materials were in abundant supply, then toolmakers could select suitable blanks from among those produced expediently rather than investing time or energy in the preparation of formal cores.

Despite the potential utility of amorphous flakes, a focus on standardized blades in the Paleoindian and earliest Early Archaic levels at Dust Cave is clear. The use of more expedient flake tools seems to increase in the later Archaic levels. While few actual cores were recovered, the presence of blades provides evidence for specialized core preparation in the early periods. Perhaps, then, conservation in production is not the issue. Instead, blades may have been produced for other reasons. Investigating the functions of these tools in order to assess the activities in which tool users were engaging may provide answers to the question of what made specialized production a more viable strategy. I will return to this issue in the following chapter.

Torrence (1983) suggests that time stress may be the primary factor governing the production of standardized cores. If efficiency in task performance is of great concern, as it often is among hunter-gatherer populations who rely on seasonally limited or highly mobile resources, then we might expect to see standardized blank production. Periods of intensive procurement and processing under such conditions requires that large numbers of tools are available and ready to use while away from raw material sources. Toolmakers might have responded to these demands by producing standardized cores from which large numbers of blanks could be removed. These flakes could then be transformed rapidly into tools, with little effort expended. If, on the other

hand, populations exploited less mobile and more ubiquitous resources, there might have been fewer constraints on time available for processing. Under these conditions, we might expect to see less reliance on specialized tool production, as tools could have been manufactured as needed.

Perlès (1992) considers technical or functional needs and constraints to be primary concerns governing the production of standardized cores. In her discussion of blade manufacture, she suggests that “The production of predetermined (often standardized) blades can also be stimulated by technical constraints that, strictly speaking, do not arise from the ultimate function of the tool but from its particular mode of utilization” (Perlès 1992: 238). For example, standardized haft elements facilitate interchangeability, replacement and easy repair of broken bits. The production of standardized haft elements is aided by the production of standardized blanks that require less modification in order to achieve the desired metrics (e.g., width and thickness of the proximal end). As another example, if circumstances require a large number of cutting implements (e.g., under conditions of intensive butchering), blade manufacture on polyhedral cores is a reasonable choice, as many straight edges can be produced with fairly little effort after the initial investment in core preparation. At Dust Cave, though, blade production appears not to have been achieved through the use of polyhedral cores, but instead through the creation of specialized cores from which single, large blades were derived (Meeks 1994). The product was similar to blades derived from polyhedral cores, though, being parallel-sided, long, and narrow. While straight edges can be created through secondary blank modification, blades require little or no additional modification in order to make excellent cutting tools, and may be more useful initially because the edge is not being “dulled” by secondary flaking in order to create the straight edge. Instead, the blade begins its use-life with a thin, sharp, immediately

usable edge. Ellis (1984: 444) has proposed that some tool forms may, in fact, be impossible to create through secondary modification alone. Characteristics such as curvature or minimal thickness may be difficult to produce post-detachment, and may therefore need to be inherent to the blank itself.

Parry and Kelly (1987: 298) and Perlès (1992: 233-234) suggest that tool maintenance requirements may also influence the decision to use standardized cores for blank manufacture. Using standardized cores may allow toolmakers to produce blanks and tools that possess characteristics such as particular tool dimensions or haft dimensions that facilitate use-life extension or tool recycling. Such a strategy would be useful under conditions in which tool use is relatively continuous, allowing recurrent episodes of maintenance and rejuvenation as part of the use process.

Producing standardized cores and blanks may also facilitate transportation by reducing tool bulk at the point of initial manufacture. Smaller tool blanks may be packed and transported more easily (see Bamforth 2002: 58; Parry and Kelly 1987: 298; Perlès 1992: 234). Standardized production may also allow the creation of a range of very flexible blank forms that can be used in the manufacture of a wide variety of tool types (Parry and Kelly 1987: 298), which confers great advantages to mobile hunter-gatherer populations who are concerned with tool transport costs.

To summarize, standardized core and blank production appears to enable efficient use of time in the production of blanks. If toolmakers can produce blanks that possess characteristics that are appropriate for meeting particular technological and functional needs, then the time necessary for subsequent tool modification is reduced, which can be an important consideration to groups that are highly mobile or that experience time stress in procurement or processing activities as a result of pursuing seasonally limited resources or focusing on a limited range of

resources. Production of standardized cores may also facilitate transportation of blanks and tools by reducing waste at the raw material source, enabling toolmakers to transport only the most useful portions of raw material. This, again, would be an important consideration for mobile groups. Finally, the production of standardized cores and blanks enables potentially greater flexibility in tool production, particularly when toolmakers were in locations removed from the raw material source. Under the right set of circumstances, then, the investment of time and energy in producing standardized cores may very well be outweighed by the advantages conferred by the production of standardized blanks. This argument for the utility of standardized core production is highly context-dependent, though.

It is clear that there are advantages to producing standardized cores and blanks, but we see many cases in the archaeological record, including in the later levels at Dust Cave, of the use of much less standardized, more haphazard production techniques. I turn now to consideration of the circumstances under which toolmakers might opt to shift to more unstandardized production.

Even when attempting to produce a preconceived tool form, it is possible for the toolmaker to begin with a non-standardized blank, derived from a more haphazardly produced core, and to apply secondary modification to transform the blank into the desired tool form. One factor that may influence the decision to rely on less standardized production is the nature of available raw materials. First, production of formal cores might not be possible simply because of the low quality of available materials. This does not appear to have been a concern at Dust Cave where, even in later periods when we do see use of less standardized blanks, toolmakers were focusing primarily on high-quality Blue-Grey Fort Payne chert.

The use of non-standardized cores might also be related to the presence of certain technical constraints. Not all tool requirements can be achieved through core preparation.

Producing characteristics such as particular edge forms, edge angles, and hafting modifications may require the application of secondary modification. Even without application of secondary modification, flakes from unstandardized or unprepared cores may be more useful under particular circumstances. Parry and Kelly (1987: 299) have argued that much of the finished tool form is dependent on the initial form of the blanks, which means that standardized core production may not be as useful for the production of certain tool forms simply because of the consistency in edge forms that can be produced through some types of core preparation. Expediently produced flakes that are less standardized in form, however, tend to yield a wider variety of edge forms, and may therefore provide a wider pool of useful forms from which the toolmaker may choose.

The use of less standardized cores may also be related to raw material constraints. If toolmakers use a wide range of materials, or if raw materials are ubiquitous in the environment, then raw material conservation may not be a primary concern. If this is the case, then toolmakers may opt to use a less prepared core technology for the more expedient production of blanks, as these can be produced quickly and easily, and create usable flakes with extremely sharp edges, if left unmodified (Ellis 1984: 453; Parry and Kelly 1987: 298). Johnson (1987: 11) also suggests that using amorphous or unstandardized cores reduces the time required for production and allows the creation of a variety of blank edge shapes and angles, which allows greater flexibility in future tool production options. This is not to say that great technological and functional flexibility cannot also be achieved through the use of more standardized cores. But toolmakers must make decisions regarding at what point in the technological sequence to invest their time or energy.

The arguments regarding the selection of standardized or unstandardized core production techniques can be summarized as follows: “the choice of expedient over formal core technology involves a tradeoff between the costs of transporting tools and raw materials (which are high for expedient core technology and low for formal or standardized core technology) and the costs of manufacturing and using tools (relatively high for formal, lower for expedient)” (Parry and Kelly 1987: 299). Determining these costs requires toolmakers to consider raw material availability across the landscape, range and frequency of settlement mobility, and the demands of tasks in which tools were used. In cases of high mobility, raw material scarcity, or particularly demanding task performance, standardized technologies might be preferred. In contrast, toolmakers might elect to use a less standardized technology under conditions of low residential mobility, raw material ubiquity, or less demanding functional requirements. Because the variety of tasks and the degree of mobility may vary throughout the year, toolmakers may produce both formal and informal tools to meet a variety of needs. The decision regarding which strategy to emphasize at which time is, therefore, a highly context-dependent one.

Assessing Standardization: Biface Tools

Categorizing a tool as a bifacial implement necessarily implies that it has received at least some degree of intensive post-detachment modification, as the piece was flaked on both the dorsal and ventral faces around the entire perimeter of the specimen. In later production stages, bifaces tend to exhibit more refined flaking that extends well onto the surface of the tool. Even tools from earlier in the production sequence may exhibit fairly extensive flaking.

From the Flaking Index, discussed in Chapter 4, we see that the categories of Early Stage and Mid Stage Bifaces exhibit less refined flaking, and are less formal in appearance than their

later stage counterparts. The categories of Trimmed Bifaces (I and II) exhibit more refined flaking, although the morphology of these tools has not achieved the level of formality we see in the very latest stage of biface manufacture. The Hafted and Probable Hafted Bifaces are the most refined specimens and exhibit hafting modifications, which produce a formal and often standardized proximal morphology.

Because these specimens have been modified quite significantly, it generally is difficult if not impossible to identify the core type from which blanks were derived. In some cases, these implements may not have been produced from blanks, but instead were reduced bifacially from the original piece of raw material. Rather than attempt to assess standardization in core production for these implements, I will focus only on standardization in tool modification.

Early and Mid Stage bifaces represent the early part of the reduction sequence, prior to the creation of final tool dimensions and, therefore, we might expect to see little standardization in the measurements of these tools. The Trimmed Bifaces (I and II), on the other hand, had begun to develop a much more refined shape. These tools may have served as hand-held knives or as preforms for hafted bifaces and, therefore, may be expected to exhibit greater degrees of standardization. The Hafted and Probable Hafted Bifaces as well as hafted bifacial Drills might also be expected to exhibit greater degrees of standardization, especially if easy replacement of broken bits was a priority to toolmakers. While the Hafted Bifaces are not considered in detail here, other hafted implements, such as certain of the unifacial Scraper categories, are studied. Evaluation of standardization in proximal measurements may serve to provide insight into this possibility.

Because of the small sample sizes, I was unable to assess degrees of standardization among the Early Stage Bifaces. These tools likely represented an early stage in the production

sequence, so my expectation would be for little standardization, as toolmakers were only beginning to produce the final form of bifacial implements at this early stage. My analysis of standardization among stage bifaces therefore begins with the Mid Stage Bifaces. Somewhat surprisingly, given the still fairly early position of these tools in the reduction sequence, Mid Stage Bifaces exhibit moderate to very high levels of standardization. In other words, these tools exhibit fairly great consistency in their lengths, widths, and thicknesses. Each of these attributes exhibited moderate, high, or very high levels of standardization in all periods (see Tables 7.18, 7.19, 7.20, 7.21).

Table 7.18: Standardization in Mid Stage Bifaces, Early Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	10	63.62	17.87	28.09	Moderate
Width	10	47.95	8.14	16.98	High
Thickness	10	8.84	4.04	21.44	Moderate

Table 7.19: Standardization in Mid Stage Bifaces, Mid Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	7	47.11	8.43	17.89	High
Width	7	43.35	11.55	26.64	Moderate
Thickness	7	16.93	1.69	9.98	Very High

Table 7.20: Standardization in Mid Stage Bifaces, Late A Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	8	63.28	12.13	19.17	High
Width	8	45.16	5.81	12.87	High
Thickness	8	15.29	2.83	18.51	High

Table 7.21: Standardization in Mid Stage Bifaces, Late B Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	5	63.86	63.86	21.53	Moderate
Width	5	56.56	4.36	7.70	Very High
Thickness	5	16.99	2.85	16.77	High

Compared to the degree of variability seen in the categories of Trimmed Bifaces, discussed below, the Mid Stage Bifaces show much greater standardization in the basic dimensions of length, width, and thickness. This high degree of standardization might be explained as the result of toolmakers setting up bifaces for appropriate later stage biface dimensions; as the product of cobble size; or, if these tools also served as cores for blank production, as a function of the process of reduction, in which bifaces were discarded once they became reduced sufficiently that the flakes being removed were too small to be transformed into other tool types. It may also be a function of the unrepresentative nature of the small sample.

The collection of Trimmed Biface I specimens is largely fragmentary, being represented primarily by proximal, distal, and medial fragments. The majority of these tools were broken transversely, possibly during manufacture, making assessments of standardization in length impossible. In light of this pattern, I consider standardization only in their widths and thicknesses. The TBI specimens exhibit generally moderate or lower levels of standardization in these attributes, with variability evident in all time periods (Tables 7.22, 7.24, 7.25, 7.26, 7.27, 7.28, 7.29). In general, degrees of standardization are lower than those noted for the Mid Stage Bifaces.

Table 7.22: Standardization in TBI, Early Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	18	6.83	28.40	24.05	Moderate
Thickness	18	2.17	8.52	25.47	Moderate

Table 7.23: Standardization in TBI, General Early. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	13	10.35	30.30	34.16	Low
Thickness	13	2.84	9.80	28.98	Moderate

Table 7.24: Standardization in TBI, Mid Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	68	8.27	30.94	26.73	Moderate
Thickness	68	2.51	9.34	26.87	Moderate

Table 7.25: Standardization in TBI, General Mid. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	34	7.57	30.63	24.71	Moderate
Thickness	34	2.59	10.18	25.44	Moderate

Table 7.26: Standardization in TBI, Late A. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	26	9.70	34.47	28.14	Moderate
Thickness	26	4.23	11.14	37.97	Low

Table 7.27: Standardization in TBI, General Late A. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	47	7.49	33.23	22.54	Moderate
Thickness	47	2.87	10.27	27.95	Moderate

Table 7.28: Standardization in TBI, Late B. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	13	11.15	33.97	32.82	Low
Thickness	13	3.13	10.33	30.30	Low

Table 7.29: Standardization in TBI, General Late B. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	26	8.14	29.93	27.20	Moderate
Thickness	26	2.94	9.49	30.98	Low

It is somewhat surprising that these tools, which I argue had progressed further through the reduction sequence, exhibited lower levels of standardization. However, this pattern may be a reflection of the fact that, as Hafted Bifaces were being produced from these earlier Trimmed Biface preforms, standardization of the *proximal* measurements became a greater concern to toolmakers. Even if this was the case, though, we might expect to see some limits on other dimensions in the production of Hafted Bifaces, as some implement sizes might have made spear tips so small as to be useless, too large as to be unwieldy, too thick to allow penetration, or so thin as to be too fragile for use.

Similar degrees of variability are noted among the Trimmed Biface II specimens (Tables 7.30, 7.31, 7.32, 7.33, 7.34, 7.35, 7.36, 7.37). As with the Trimmed Biface I artifacts, these tools

are mostly fragmentary, meaning that assessments of length are problematic. Width and thickness measurements show similarly low and moderate levels of standardization to those noted among the TBI specimens. Compared to the Trimmed Biface I sample, though, thickness appears to become slightly more standardized, as the degree of standardization is classified as “moderate” for all periods. This may indicate a focus on refining this particular tool dimension later in the reduction sequence. As was the case with the Trimmed Biface I tools, the proximal measurements of the Trimmed Biface II specimens may have become of greater concern than the basic dimensions of length, width, and thickness as these items were refined. The low levels of standardization in width may reflect the fact that width measurements may not represent the same point on the tool, as most of these specimens are fragmentary. In other words, rather than measuring width at the longitudinal midpoint of the tool, width may have been measured slightly proximally or slightly distally from this point on the broken pieces.

I have avoided discussion of standardization in the category of bifacial drills for two reasons. First, the measurements of overall length, width, and thickness, which are considered for the other bifacial implements, are not the most important dimensions to consider for drills. Instead, standardization of bit measurements and proximal measurements would be more informative. Because of the fragmentary nature of many of the specimens, though, sample sizes were too small to allow statistical tests to be run.

Table 7.30: Standardization in TBII, Early Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	36	8.32	25.50	32.63	Low
Thickness	36	2.37	7.39	32.07	Low

Table 7.31: Standardization in TBII, General Early. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	14	8.27	24.46	33.81	Low
Thickness	14	1.65	7.18	22.98	Moderate

Table 7.32: Standardization in TBII, Mid Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	68	7.82	24.65	31.72	Low
Thickness	68	1.64	6.65	24.66	Moderate

Table 7.33: Standardization in TBII, General Mid. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	47	8.81	22.79	38.66	Low
Thickness	47	1.35	6.87	19.65	High

Table 7.34: Standardization in TBII, Late A Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	63	8.12	27.08	29.99	Moderate
Thickness	63	1.75	7.51	23.30	Moderate

Table 7.35: Standardization in TBII, General Late A. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	50	7.14	24.67	28.94	Moderate
Thickness	50	1.75	7.21	24.27	Moderate

Table 7.36: Standardization in TBII, Late B Period. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	30	7.05	32.55	21.66	Moderate
Thickness	30	1.96	8.19	23.93	Moderate

Table 7.37: Standardization in TBII, General Late B. (Primary measurement data available in Appendix A, Table A-1.)

Attribute	Frequency	Standard Deviation	Mean	Coefficient of Variation (%)	Degree of Standardization
Width	49	9.03	25.77	35.04	Low
Thickness	49	1.71	7.09	24.12	Moderate

Bifaces: Summary

To summarize, the results of tests of standardization among the bifacial implements were somewhat surprising. I expected stage bifaces to represent progression through the bifacial reduction sequence. In this case, I would have anticipated seeing greater degrees of standardization as progressively more post-secondary modification was applied to produce the desired final form. It is assumed that this “final form” represented any of the range of temporally diagnostic Hafted Bifaces recovered from the site. Instead, the highest degrees of standardization were recorded in the earlier Mid Stage specimens, while greater variability was noted among the later stage Trimmed Biface I and II tools. As discussed above, this may be partly a function of the measurement of fragmentary specimens. While thickness tended to be moderately standardized in both TBI and TBII specimens, with a few exceptions, width was more variable and may represent inconsistencies in the position at which the measurement was taken on the tool.

Apart from the possible bias introduced by measuring fragmentary specimens, I suggest several other possible explanations for this unexpected pattern. First, the earlier stage bifaces might not actually indicate earlier stages in the production of only Hafted Bifaces. The greater degrees of variability noted among later stage specimens instead might represent preforms splitting into separate reduction trajectories, progressing toward the creation of a variety of tool types beyond simply projectile tips or hafted knives. Second, particular dimensions (e.g., proximal haft measurements) might have been more important to standardize in the manufacture of hafted bifaces. Projectile tips certainly need to be long enough and thin enough to penetrate prey effectively but not so long or so thin as to break easily on impact. There are, therefore, upper and lower limits on effective dimensions, but precise length, width, and thickness measurements may not have been as crucial when compared to other attributes, such as proximal dimensions and haft morphology, or edge angles produced for carrying out certain tasks. Standardization of width might be an important consideration particularly in the production of thrusting spears. Width measurements in line with the haft would facilitate removal of the spear without snagging on the flesh. On the other hand, thrown spears or dart points likely would have performed better if they remained embedded in the prey, inflicting maximum injury and producing a blood trail that could be tracked easily if the animal fled. In this case, maintaining a width in line with the haft might have been of less concern. In light of the variable patterns noted in this class of artifacts, I suggest that flaking index is a much better indicator of reduction stage than is degree of standardization in tool dimensions.

I was unable to make any assessment of standardization in the bifacial drill specimens, as so few complete examples were recovered. Had complete specimens been recovered in any great number, an assessment of standardization in the basic dimensions (overall length, width,

thickness) would have been relatively unimportant. Bit measurements and proximal dimensions would have been more useful to consider. Too few complete or relatively complete specimens were recovered to allow these measurements to be considered.

Assessing Standardization: Flake Tools

Flake tools have great potential to inform us about standardization in core preparation and blank production, as flake implements often retain characteristics of the original blank, which can be used to interpret the core type from which that blank was derived. Several categories of flake tools were examined in this collection, including formal and informal variants of several classes. Formality, in this case refers to the degree of refinement of the final tool form rather than to the degree of investment in core preparation. Nevertheless, I do consider the relationship between degree of post-detachment modification applied in order to create a formalized implement, and the nature of core production.

In assessing the production and degree of standardization of flake tools, I consider several issues, including: what core types were being used in the production of particular tool classes; how much effort was invested in post detachment modification of various tool classes and sub-classes; whether or not haft measurements were standardized within various classes of hafted implements; and the nature of the relationship between core types and the degree of secondary modification applied in the production of flake tools.

Among the flake tools I studied are numerous examples of intentionally and unintentionally modified flakes (RFL and UFL, respectively). By definition, these tools exhibit little or no secondary modification. Intentionally Modified Flakes (RFL) are worked to a minimal degree, but the modification is applied only to alter the working edge slightly in order to

make it more appropriate to the task at hand rather than as a means of creating a distinct outline morphology. Unintentionally Modified Flakes (UFL), on the other hand, exhibit no purposeful modification, and were flaked or damaged incidentally through use.

Several scraper varieties were identified (SCR) and were distinguished based on the location of the working edge (e.g., end scraper, side scraper, etc.). Sub-varieties were identified within certain Scraper classes, based on characteristics such as the degree of dorsal modification, or the degree to which the proximal end was modified for hafting purposes. For example, certain End Scrapers exhibited complete dorsal modification in order to produce a highly refined shape, while others were modified only marginally.

I include Blade Scrapers in my discussion, as these tools likely served similar functions as the scrapers produced on other blank types. By definition, these are produced from standardized blanks removed from prepared blade cores. The use of standardized blanks may have influenced the degree of investment in secondary modification.

In the following sections, I present data on blank selection for the various tool classes, and consider the amount of post-detachment modification applied to various tool types, particularly in relation to selected blank types.

Scrapers (ESCR, SSCR, BSCR, OSCR, HSCR)

In the following four sections, I consider the sub-types of scrapers and discuss the manufacture of those variants from the perspective of blank/core types used, degree of post-detachment modification applied, and standardization of their measurements. The scraper data are broken down according to the degree of post-detachment modification that was applied to blanks. Specimens that received only marginal modification that did not extend onto the surface

of the tool are recorded in Appendix A under the category “MF” (marginally flaked), while those that received extensive dorsal modification are classified as “CD” (complete dorsal). In addition to these two categories, I also consider the Scrapers that were produced from specialized blade flakes. It is important to recognize that sample sizes are small, which makes statistical comparisons difficult or impossible, but some general observations can be made about the Scraper variants.

End Scrapers

Examination of the End Scraper (ESCR) data (see Table 7.38) shows that the majority of End Scraper specimens (n=26 of 39 total) were recovered from the Early period, which includes the Paleoindian zones. Of these 26 specimens, 20 retained characteristics that allowed blank types to be identified. Nearly half (n=9) were produced from specialized blades, and all blade specimens exhibited only marginal flaking, which suggests that little additional modification was necessary to produce the desired tool form. The majority of flaking was applied in order to modify the morphology and angle of the distal (working) end of the blank. It is possible that the use of standardized blanks may have facilitated hafting without substantial additional investment in blank modification. I will investigate this possibility in more detail in my discussion of tool measurements and standardization.

The remaining marginally flaked Early End Scraper specimens were produced from only two core types: multidirectional/amorphous cores (n=3), and cobble cores (n=1). The cobble specimen likely represents a flake removed during the initial reduction or decortication of a cobble and, therefore, might also be classified as an amorphous blank.

Table 7.38: End Scraper Blank Types and Modification Types by Period. (Data available in Appendix A, Table A-3.)

Period	Dorsal Flaking	Blade	Biface	Multidirectional	Blocky	Blade-Like	Cobble	?	Total
Early	CD		1	2	2	2		3	10 (7)
	MF	9		3			1	3	16 (13)
Middle	CD			2	1			3	6 (3)
	MF	1		1				1	3 (2)
Late	CD							1	1 (0)
	MF					2		1	3 (2)
Total		10	1	8	3	4	1	12	39 (27)

Those Early Period End Scraper specimens that received complete dorsal modification were produced on blanks from a wider variety of core types, including: biface (n=1), multidirectional/amorphous (n=2), blocky (n=2), and blade-like (n=2). These varied core types would have produced blanks of various sizes and shapes. Achieving the desired tool form would have necessitated the application of greater amounts of post-detachment modification. The production of End Scrapers from the Early period seems to have emphasized the use of easily modified blades, with only minimal use of less standardized blank forms.

Less patterning is apparent in blank selection in the Middle and Late A/B periods. This apparently greater variability in blank selection may be related in part to the smaller sample sizes, which appear to represent a decrease in the popularity of Scrapers, especially End Scrapers, after the earliest part of the Early Archaic. Alternatively, it may reflect less concern with producing standardized elements among tools that were becoming less dominant in the technological inventory.

Examination of the specimens produced from non-blade flakes reveals overall quite high degrees of standardization in tool dimensions and attributes among the dorsally flaked and marginally flaked End Scrapers (see Tables 7.39, 7.40, 7.41, 7.42, 7.43). Higher degrees of standardization (i.e., low variability) were noted among the earlier specimens, from the Early and Mid zones, while lower degrees of standardization were seen in the Late period specimens.

Several attributes exhibited greater standardization more consistently across time periods. These attributes included width, proximal thickness, bit width, and bit angle. Consistency in width measurements may be related to the frequent use of blades in the earlier periods. Because of the specialized and more standardized mode of blank production, these blanks may have been produced with similar widths initially. Another possibility is that similarity in widths represents intentional modification of the blank to facilitate hafting.

Proximal thickness exhibited high or very high levels of standardization in all periods. Proximal width, on the other hand, tended to be more variable. It appears, then, that standardization of proximal thickness was of greater concern to tool manufacturers than was the standardization of proximal width. One possible explanation for this pattern is that the types of cores being used in blank manufacture simply were producing blanks with more consistent proximal measurements. While this explanation might be reasonable if toolmakers were relying on a particular core type (e.g., blade cores), several different core types were represented in the end scraper sample.

Table 7.39: Standardization in Dorsally Flaked End Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	11	36.51	11.23	30.76	Low
Width	11	23.52	2.81	11.95	High
Thickness	11	8.29	2.34	28.22	Moderate
Prox. Width	8	15.40	3.12	20.26	Moderate
Prox. Thickness	8	7.06	1.56	22.10	Moderate
Bit Width	9	24.41	3.39	13.89	High
Bit Thickness	9	7.63	2.18	28.57	Moderate
Bit Depth	9	7.38	2.92	39.57	Low
BW:BD	9	3.66	1.12	30.60	Low
Bit Angle	9	70.56	7.05	9.99	Very High
Lateral Expansion	12	23.33	9.96	42.69	Unstandardized

Table 7.40: Standardization in Marginally Flaked End Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	6	37.75	9.64	25.54	Moderate
Width	6	24.61	4.24	17.23	High
Thickness	6	8.09	2.80	34.61	Low
Proximal Width	3	18.46	0.93	5.04	Very High
Proximal Thickness	4	7.75	1.49	19.23	High
Bit Width	3	30.43	3.90	12.82	High
Bit Thickness	5	6.41	1.41	22.00	Moderate
Bit Depth	3	6.68	2.03	30.39	Low
BW:BD	3	4.70	0.78	16.60	High
Bit Angle	6	60.42	9.14	15.13	High
Lateral Expansion	3	20.83	7.64	36.68	Low

Table 7.41: Standardization in Completely Dorsally Flaked End Scrapers, Mid Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	5	40.03	10.65	26.61	Moderate
Width	5	25.67	4.56	17.76	High
Thickness	5	8.36	0.94	11.24	High
Proximal Width	5	13.86	4.81	34.70	Low
Proximal Thickness	5	6.27	1.05	16.75	High
Bit Width	5	27.11	4.82	17.78	High
Bit Thickness	5	8.65	0.69	7.98	Very High
Bit Depth	5	7.50	2.84	37.87	Low
BW:BD	5	3.97	1.46	36.78	Low
Bit Angle	5	65.00	6.61	10.17	High
Lateral Expansion	3	29.17	17.56	60.20	Intentionally Different

Table 7.42: Standardization in Marginally Flaked End Scrapers, Mid Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	2	38.71	2.77	7.16	Very High
Width	2	26.69	0.54	2.02	Very High
Thickness	2	9.52	0.17	1.79	Very High
Proximal Width	2	18.84	6.15	32.64	Low
Proximal Thickness	2	7.56	0.51	6.75	Very High
Bit Width	2	26.92	3.80	14.12	High
Bit Thickness	2	5.24	4.31	82.25	Intentionally Different
Bit Depth	2	8.55	1.97	23.04	Moderate
BW:BD	2	3.19	0.29	9.09	Very High
Bit Angle	2	73.75	5.30	7.19	Very High
Lateral Expansion	2	27.50	21.21	77.13	Intentionally Different

Table 7.43: Standardization in Marginally Flaked End Scrapers, Late A. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	3	31.15	9.07	29.12	Moderate
Width	3	21.46	3.97	18.50	High
Thickness	3	6.36	3.42	94.21	Intentionally Different
Proximal Width	2	18.12	5.54	30.57	Low
Proximal Thickness	2	7.82	3.88	49.62	Unstandardized
Bit Width	3	21.81	3.98	18.25	High
Bit Thickness	3	5.54	2.67	48.19	Unstandardized
Bit Depth	3	3.55	0.95	26.76	Moderate
BW:BD	3	6.35	1.47	23.15	Moderate
Bit Angle	3	71.67	13.77	19.21	High
Lateral Expansion	3	19.17	7.64	39.85	Low

Another explanation for the consistency in proximal thickness is that proximal dimensions were being altered for the purpose of hafting so that the proximal end of the tool would fit easily into a pre-made haft. Standardization of the haft end would facilitate easy replacement of broken stone bits during intensive periods of use, and would allow re-use of the haft elements, which are more costly to produce, in terms of production effort (Rule and Evans 1985). Among the Early period specimens, we see significant differences in mean proximal widths of each of the categories of End Scrapers (CD, MF, and Blade End Scrapers). On the other hand, no significant differences were noted in mean proximal thickness among these same End Scraper categories (see results of Kruskal-Wallis Test, below; Table 7.44). In addition to standardization *within* categories, toolmakers appear to have been concerned with producing tools that exhibited consistency in proximal thickness *across* categories (i.e., regardless of blank

type). The apparent lack of concern over proximal width, and the corresponding emphasis on standardized proximal thickness, suggest the use of split shafts rather than socket hafts. This possibility is bolstered by the fact that lateral expansion was also highly variable in all periods. Split shafts allow for greater variability in the degree of lateral expansion, while socket hafts, which envelop the proximal end of the tool, might require the production of tools with less dramatically expanding lateral margins.

Examination of bit characteristics revealed high degrees of standardization in both bit width and bit angle, but not in bit depth or thickness. Consistency in bit width may be related to consistency in overall width. Bit angle, which is highly standardized, may reflect functional needs in the application of these tools to hide scraping, which is the assumed function of these implements (see microwear results in Chapter 8), and/or a function of resharpening changes and the timing of discard. Wilmsen (1970) suggested that more acute bit angles ($\sim 55^\circ$) were appropriate for hide scraping and meat cutting, while steeper bits ($\sim 75^\circ$) were more appropriate for scraping or whittling bone or wood. Recent reevaluation of Wilmsen's work, however, has suggested that a wider range of bit angles may be appropriate for hide scraping (Comstock 2011; Seeman et al. 2013). Comstock (2011) and Seeman et al. (2013) propose that the ability to maintain a sharp scraping edge and to resharpen the tool repeatedly may be of greater concern to toolmakers and tool users than is the maintenance of a particular distal edge angle (Comstock 2011; Seeman et al. 2013). The standardization in bit angle noted here may, therefore, represent an artifact of the resharpening process and the decision to retool (i.e., to replace a used bit with a new bit that has the greatest potential for rejuvenation) prior to embarking on the next round of hide preparation. This possibility will be discussed in greater detail below.

Several Early period End Scrapers were produced from blades, which generally are assumed to be a more standardized blank form. I compare these specimens to those End Scrapers produced on non-blade flakes. High degrees of standardization were noted in width, thickness, bit width, and bit angle (Table 7.45). Moderate levels of standardization were recorded for length, proximal width, proximal thickness, and bit thickness. Only bit depth and bit width-to-depth ratio exhibited low standardization or a complete lack of standardization, respectively. The high degrees of standardization in width and thickness are likely related to the use of blade blanks for production of these tools. Fairly consistent dimensions can often be achieved in blade manufacture, and the minimal amounts of modification applied to the margins of these tools, after detachment of the blank, could have refined the measurements even further. The high degree of standardization in bit width may be related in part to standardized tool width measurements, while the highly standardized bit angles may reflect either functional requirements, or the timing of tool discard and retooling (see discussion above; Comstock 2011; Seeman et al. 2013).

In the sample of Early period specimens, moderate levels of standardization were noted for both proximal width and proximal thickness. An initial examination of the coefficients of variation for both of these dimensions suggest greater variability among the blade specimens than among those produced on other flake types. Comparison of the coefficients of variation using the D'AD statistic, however, reveals no significant differences in the CV values for any of these measurements (95% confidence interval; Table 7.46). The coefficients of variation for the proximal widths of the Blade End Scrapers and marginally flaked non-blade End Scrapers come the closest to exhibiting a significant difference but still are not significant at the 95% confidence interval. While mean proximal width varied significantly among the specimens produced on non-

blade vs. blade flakes, mean proximal thickness did not. The similarity in proximal thickness measurements across the blank type and modification type categories, in association with the consistency noted in levels of standardization, suggests that all of these tools were being produced to exhibit consistent proximal thicknesses, likely in order to facilitate replacement of the stone bits in curated hafts that were retained through multiple episodes of use. Tools with consistent proximal thickness measurements may have been inserted into split hafts, like the split antler haft that was recovered from the site.

Table 7.44: Results of Kruskal-Wallis Test for differences in Proximal Width and Proximal Thickness among Early Period End Scrapers. (Primary measurement data available in Appendix A, Table A-3.)

Ranks			
	VARIETY	N	Mean Rank
PWID	CD	9	6.11
	MF	3	8.33
	BLD	4	14.00
	Total	16	
PTHK	CD	9	8.78
	MF	3	8.33
	BLD	4	8.00
	Total	16	

Test Statistics ^{a,b}		
	PWID	PTHK
Chi-Square	7.608	.078
df	2	2
Asymp. Sig.	.022	.962

a. Kruskal Wallis Test

b. Grouping Variable: VARIETY

Table 7.45: Standardization for Blade End Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	9	45.02	12.47	27.70	Moderate
Width	9	30.61	4.45	14.53	High
Thickness	9	6.74	1.11	16.47	High
Proximal Width	4	24.88	6.86	27.57	Moderate
Proximal Thickness	4	7.49	1.81	24.17	Moderate
Bit Width	9	31.94	6.37	19.94	High
Bit Thickness	9	6.52	1.38	21.17	Moderate
Bit Depth	9	8.50	3.00	35.29	Low
BW:BD	9	4.42	2.26	51.13	Unstandardized
Bit Angle	9	67.09	10.72	15.98	High

The minor variability seen in length measurements can be explained easily as a function of resharpening, and the decision to discard. Length may also be related to tool condition, as the sample included both complete and fragmentary specimens. It is also possible that variability in original blade lengths contributed to the lack of standardization.

The moderate degree of standardization noted in bit thickness may be related to moderate standardization in overall blank thickness. Blanks would have needed to be thick enough to allow production of tools and bits that would not snap under the forces exerted during hide scraping. It may be that a certain thickness allowed the production of the appropriately steep angles used in hide scraping. Distal flake ends that were too thin might not have allowed the production of steep enough bit angles or strong enough bits. The moderate degree of standardization in this attribute may, therefore, represent intentional removal of part of the length of the blank in order to achieve the desired thickness for production of the end scraper bit.

The high CV for bit depth, which represents great variability or low standardization, likely indicates varying degrees of bit resharpening. As bits are resharpened, material is

removed, reducing the length of the tool. Once the length is reduced to the point at which it begins to encroach on the juncture between tool and haft, it becomes progressively more difficult to maintain the desired degree of bit convexity. At this point, material can continue to be removed from the convex middle portion of the bit, while less can be removed from the bit corners. The bit then begins to straighten, becoming less and less convex, and thus shallower. The lower degree of standardization in bit depth may be responsible for greater variability in bit width-to-depth ratio, which is used as an indicator of end scraper bit convexity.

Table 7.46: D'AD results for comparisons of proximal width and proximal thickness CVs between Blade Scrapers and non-Blade scrapers, Early Period.

Attribute	BSCR vs. CD ESCRS	BSCR vs. MF ESCR
Proximal Width	0.404673	3.331043
Proximal Thickness	0.031587	0.630081

Following Eerkens and Bettinger 2001: 499, D'AD is distributed as a χ^2 random variable with k-1 df. For these samples, df=1. (Primary measurement data available in Appendix A, Table A-3.)

Among both the blade scrapers and non-blade scrapers, we see high degrees of standardization in many of the same attributes, including: width, bit width, and bit angle. High and moderate degrees of standardization were also noted in proximal width. It seems, then, that those attributes most closely associated with tool function (angle of the working edge) and hafting capability (tool and haft width) were being emphasized and controlled by toolmakers.

Side Scrapers

All of the Side Scrapers (see Table 7.47) recovered from Dust Cave exhibited only marginal flaking. These specimens may overlap with the category of Ovoid Scrapers, although several of the Ovoid Scrapers had been flaked dorsally as well as marginally.

Almost all of the Side Scrapers, with one exception, were recovered from the Early zones (Late Paleoindian), and the majority of these were produced on blades (n=6 of a total 8 with identified blank types). One specimen, recovered from the Middle zones (Early Archaic) was manufactured from a multidirectional blank.

Table 7.47: Side Scraper Blank Types and Modification Types by Period. (Data available in Appendix A, Table A-3.)

Period	Dorsal Flaking	Blade	Biface	Multi-directional	Blocky	Blade-Like	Cobble	?	Total
Early	MF	6			1	1		3	11 (8)
Middle	MF			1					1
Total		6		1	1	1		3	12

Among those tools produced from non-blade flakes, most attributes exhibited fairly low levels of standardization, although these patterns likely are reflective of the very small sample size (Table 7.48). Length was moderately standardized, while width, proximal width, and proximal thickness all showed low degrees of standardization. Overall blank thickness was classified as being unstandardized. Bit (working edge) angle was the only attribute that exhibited high levels of standardization, although with so few specimens represented, the significance of this pattern is difficult to assess with any confidence. This pattern likely is reflective of functional needs or of the small size of the sample.

The low standardization of the proximal measurements suggests little concern with production of hafts. In combination with the lack of apparent hafting modifications on these specimens, this pattern suggests that the side scrapers may have served as hand-held implements. These tools might be more appropriately classified as hand-held knives, rather than as scrapers. This possibility will be assessed in greater detail in the following chapter.

The low standardization of width likely is related to differences in initial blank width as well as to the effects of resharpening, which removed material from the lateral margins of these specimens.

Several side scrapers were recovered that were produced from blades. These tools were also excavated from the earlier zones (Zones U and T). Apart from length and bit angle, most of the attributes examined exhibited low degrees of standardization (thickness, proximal width, proximal thickness) or were unstandardized (width; Table 7.49). Length was very highly standardized, perhaps suggesting standard blank size. It is more likely, though, that this apparent extremely high degree of standardization is related to the low sample size ($n=3$). The high standardization of bit angles likely is a function of small sample size, although it may also reflect functional requirements. Unstandardized proximal measurements may represent a lack of concern over hafting, while unstandardized widths may be a function of differential material removal during edge resharpening. It is probable, though, that all of these patterns are artifacts of the small sample size.

Table 7.48: Standardization in Side Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	8	66.07	16.49	24.96	Moderate
Width	8	37.61	11.69	31.08	Low
Thickness	8	10.68	4.61	43.16	Unstandardized
Proximal Width	7	31.85	10.81	33.94	Low
Proximal Thickness	7	10.74	3.86	35.94	Low
Bit Angle	7	60.71	10.68	17.59	High

Table 7.49: Standardization in Blade Side Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	3	62.01	4.40	7.10	Very High
Width	3	54.89	24.90	45.36	Unstandardized
Thickness	3	10.40	3.67	35.29	Low
Proximal Width	3	40.93	13.33	32.57	Low
Proximal Thickness	3	10.61	4.14	39.02	Low
Bit Angle	3	58.77	6.93	11.79	High

Ovoid Scrapers

As suggested above, the Ovoid Scrapers may represent a subset of Side Scrapers, perhaps having served similar functions. They differ, however, from a technological standpoint, as these implements include both marginally flaked and dorsally flaked specimens. Most are marginally flaked but still exhibit a distinctly ovoid outline. Most Ovoid Scrapers were recovered from the Early (Paleoindian) zones. Very little patterning is apparent in the selection of blank types, with the small sample having been produced from a variety of cores, including blade, biface, multidirectional, and cobble-derived flakes (Table 7.50).

Nearly all of the Ovoid specimens were recovered from the Early zones (Zones U, T, S2, and General Early). One specimen was assigned to the Mid period Zone R. Among the dorsally flaked specimens, moderate to high levels of standardization were noted in all attributes except proximal thickness, which exhibited low standardization (Table 7.51). Length and width were both highly standardized. This high level of standardization may reflect the toolmakers' desire to produce a particular shape with specific dimensions or may be an artifact of the small sample size.

Standardization of the working edge angle is not surprising because, as discussed above, certain edge angles may be more or less suitable to the execution of particular tasks. While this pattern may again be related to the small size of the sample, it is also quite probable that it represents functional requirements associated with this tool class.

Table 7.50: Ovoid Scraper Blank Types and Modification Types by Period. (Primary measurement data available in Appendix A, Table A-3.)

Period	Dorsal Flaking	Blade	Biface	Multi.	Blocky	Blade-Like	Cobble	?	Total
Early	MF	2	1	1				2	6 (4)
	CD						1	2	3 (1)
Middle	CD		1	1					2
Total			1	1			1	2	5 (3)

Proximal width is only moderately standardized. This lack of consistency in proximal width measurements, in association with the low standardization noted for proximal thickness, suggests little emphasis on hafting modifications. It is quite likely that these implements were hand-held, a possibility that will be considered in greater detail in the following chapter.

Table 7.51: Standardization in Completely Dorsally Flaked Ovoid Scrapers, Early Period.
(Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	3	79.57	10.72	13.47	High
Width	3	45.30	6.06	13.38	High
Thickness	3	17.92	3.91	21.82	Moderate
Proximal Width	3	35.16	8.70	24.74	Moderate
Proximal Thickness	3	11.12	3.31	29.77	Low
Bit Angle	3	65.00	6.61	10.17	High

Similar, but not identical, patterns are noted among the marginally flaked specimens (Table 7.52). Width is highly standardized, but length is only moderately standardized, although the CV indicates that its degree of standardization lies between moderate and high levels (CV = 21.77). Some consistency in both width and length may reflect intentional production of standard outline morphology and standard dimensions by toolmakers or may be a reflection of small sample size. I found the high level of standardization in width measurements to be a little surprising, as lower degrees of standardization might be expected for tools that were being resharpened along their margins. Marginal flaking removes material from the lateral margins of the tool, thus progressively reducing tool width. The fact that this dimension exhibits higher degrees of standardization suggests that these tools may have been reduced fairly consistently, or it may be a function of small sample size.

As with the dorsally flaked specimens, the marginally flaked Ovoid Scrapers exhibited high standardization of the working edge angle. A D'AD test revealed no significant differences in CV values for the working edge angle between the dorsally flaked and marginally flaked end scrapers (D'AD = 0.49, df=1). The results of a Mann-Whitney U Test for equality of means

(Table 7.53) reveals no significant differences in mean working edge angle between the dorsally flaked and marginally flaked specimens, which, when considered in association with high standardization of this measurement, suggests that this particular range of angles may have had functional significance.

Proximal width measurements were also very consistent. While this pattern might suggest an emphasis on hafting modifications, there are no other indications of hafting (e.g., standardization of proximal thickness, creation of notches or stems, etc.). I am more inclined to believe that the standardization of the proximal width reflects the small sample size, or is an indicator of size requirements, perhaps to allow comfortable hand-held prehension.

Both thickness and proximal thickness were unstandardized, emphasizing the lack of emphasis on post-detachment dorsal modification within this class.

Table 7.52: Standardization in Marginally Flaked Ovoid Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	4	56.09	12.21	21.77	Moderate
Width	4	31.35	3.54	11.29	High
Thickness	4	9.91	4.02	40.57	Unstandardized
Proximal Width	3	23.24	3.43	14.76	High
Proximal Thickness	3	7.83	3.92	50.06	Unstandardized
Bit Angle	4	62.50	10.41	16.66	High

Table 7.53: Results of Mann-Whitney U Test for Equality of Mean Working Edge Angle for CD and MF Ovoid Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Ranks				
	VARIETY	N	Mean Rank	Sum of Ranks
	CD	3	4.00	12.00
BIANG	MF	6	5.50	33.00
	Total	9		

Test Statistics ^a	
	BIANG
Mann-Whitney U	6.000
Wilcoxon W	12.000
Z	-.778
Asymp. Sig. (2-tailed)	.437
Exact Sig. [2*(1-tailed Sig.)]	.548 ^b

a. Grouping Variable: VARIETY

b. Not corrected for ties.

Humpback Scrapers

Very few Humpback Scraper specimens were recovered, and almost all of them were excavated from the early zones. Specimens were also located in the Early Archaic Mid Period zones P and R. Humpback Scrapers are similar to the End Scrapers, discussed above, but exhibit a thickening toward the distal (working) end that creates the characteristic “hump” in longitudinal section.

Because these tools exhibited complete dorsal flaking, it was difficult to assess the nature of the blank types used in their production (see Table 7.54). One specimen appears to have been produced from a blocky core, while another exhibited cobble cortex, which suggests the use of a flake from an early stage of core reduction. Both of these blank types are potentially thick when

removed from the core. None of the specimens displayed characteristics of blade, biface, or blade-like blanks, all of which tend to be much thinner.

Apart from overall length and bit angle, these specimens exhibit generally unstandardized measurements. Bit angle is very highly standardized, suggesting intentional modification for functional reasons (Table 7.55). Length is also highly standardized which may reflect functional needs (e.g., a limit on length to prevent tools from snapping under the forces exerted during use). Another reason for the high standardization in these measurements might be simply that the sample size is so small that the measurements merely appear to be consistent.

All other measurements, including proximal dimensions, are unstandardized. This pattern is odd, considering that these tools appear to exhibit hafting modifications. These specimens were stemmed, suggesting their use as hafted tools, but the lack of standardization indicates that they may not have been designed for easy replacement in standardized hafts. Alternatively, they may have been hafted in socket hafts, which have a cone-shaped opening, allowing for insertion of haft elements of various sizes.

Table 7.54: Humpback Scraper Blank Types and Modification Types by Period. (Data available in Appendix A, Table A-3.)

Period	Dorsal Flaking	Blade	Biface	Multi-directional	Blocky	Blade-Like	Cobble	?	Total
Early	CD						1	3	4 (1)
Middle	CD				1				1
Total					1		1	3	5 (2)

Table 7.55: Standardization in Humpback Scrapers, Early Period. (Primary measurement data available in Appendix A, Table A-3.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	4	57.91	11.18	19.31	High
Width	4	38.04	17.36	45.64	Unstandardized
Thickness	4	19.51	8.91	45.67	Unstandardized
Proximal Width	4	18.56	9.19	49.52	Unstandardized
Proximal Thickness	4	13.41	12.38	92.32	Intentionally Different
Bit Angle	4	67.13	3.25	4.84	Very High

The humpback scrapers are highly variable artifacts. They appear to have been made on thick, unstandardized blanks, and were modified with little concern for the production of consistency in form or dimensions. It is possible that this variability indicates that they were not all being utilized for the same purpose and, therefore, do not represent a unified “class” of artifact. This possibility will be assessed further in the following chapter, in which tool function is considered.

Scrapers: Summary

Scrapers were recovered primarily from the Early levels and included End, Side, Ovoid, and Humpback varieties. Some of these tools received only marginal flaking, while others were flaked more extensively, across the dorsal surface of the blank. Among the marginally flaked End Scraper specimens, production on blades was emphasized. A few multidirectional specimens were also noted. Among the completely dorsally flaked End Scrapers, a greater variety of blank types were noted, including blades, bifacial, multidirectional/amorphous, blocky, and blade-like flakes. It appears, then, that production and selection of easily modified

blanks was being emphasized in the manufacture of marginally modified End Scrapers. A wider variety of blank types were being selected for the production of completely dorsally flaked end scrapers. This less stringent blank selection may have been mitigated by the application of significant amounts of post-detachment modification, which allowed toolmakers to achieve the same desired characteristics that were obtained with the expenditure of less effort among the marginally flaked specimens.

With the exception of one specimen from the Mid levels, all of the Side Scrapers were recovered from the Early period levels. The majority of Side Scrapers were produced from blades, which received only marginal flaking. One specimen produced from a multidirectional blank was also identified. Ovoid Scrapers, most of which were recovered from the Early levels, were produced from a variety of blank types. Among the Humpback Scrapers, few blank types were identifiable, as they had all received substantial post-detachment modification, which obliterated many original flake characteristics. Of those specimens that retained identifiable blank characteristics, one appears to have been produced from a blocky blank, while another was produced from a cobble flake.

Little can be said about changes over time in the standardization of scrapers, because almost all scraper specimens were recovered from the Early period levels, with a smaller sample excavated from the Mid period levels. Scrapers essentially disappear in the Late A and Late B levels, perhaps having been abandoned in favor of other tool types, or perhaps having been utilized at sites away from Dust Cave. These possibilities will be considered in greater detail in my later discussions.

A few patterns can be considered here, though. First, we see fairly high degrees of standardization among the Scrapers in general and, in particular, among the End Scrapers, Ovoid

Scrapers, and those specimens made on blades. All categories of Scrapers exhibited relatively high degrees of standardization in bit angle. This pattern may speak to the importance of producing a particular edge angle for functional purposes, or may be a reflection of the decision to discard. While it is possible that the timing of discard in anticipation of potential task failure, as discussed above in relation to the End Scrapers, may have influenced Side Scraper edge angle standardization, these tools appear to have been used in different sorts of tasks (see Ch. 8 for details). Maintaining a sharp working edge, therefore, may have been of less concern in the use and rejuvenation of these tools. Functional requirements, or unrepresentative samples, are a more likely explanation for the standardized Side Scraper working edge angles.

Other attributes were less consistently standardized, depending on the sub-class of Scraper considered. End Scrapers, whether produced on blades or non-blade flakes (e.g., biface, multidirectional, blocky, etc.), tended to exhibit standardization in proximal measurements, suggesting that the need for hafting modifications was a concern in the manufacture of these implements. Other Scrapers do not appear to have been hafted and, consequently, show little evidence for investment in the modification of their proximal dimensions.

Among the End Scrapers and Side Scrapers, whether marginally or dorsally modified, levels of standardization are relatively high in many of the basic tool dimensions, indicating that specimens from particular time periods were designed to be consistent. This consistency was achieved either through the application of post-detachment modification, or through minimal modification of blanks that were produced or selected to have appropriate or desirable characteristics requiring little additional modification. Reliance on either strategy is not exclusive to any time period.

Other Scraper types were designed with less consistency in their measurements. These specimens were produced on more variable flakes, and received less investment in post-detachment modification in order to make tools conform to a particular mental template.

Other Unifaces (GRV, PERF, UNF, Scraper Fragments)

In addition to the Scraper varieties, several other types of unifacial flake tools were identified and studied, including Gravers, Perforators, and several categories of general Unifaces.

All Gravers that were assignable to particular zones were recovered from some of the earliest contexts, including the Paleoindian and very earliest Early Archaic levels.

The very small sample size makes it impossible to say anything definite about blank selection in Graver production. Of the four specimens for which blank types could be identified, two were produced from multidirectional/amorphous cores, one from a biface core, and one from a blocky core, suggesting little patterning in flake selection in the production of these tools (Table 7.56).

Table 7.56: Blank Types for Gravers by Period. (Data available in Appendix A, Table A-2.)

	Blocky	Biface	Multidirectional	Unknown	Total
Zone R	1				1
Zone T		1		2	3
Zone U			2	1	3
Total	1	1	2	3	7

The small sample size also makes it impossible to consider standardization in this class of artifacts, as each temporal category contains too few specimens for any significant patterns to be apparent.

Perforators, or Unifacial Drills, were recovered from a broader selection of zones spanning the Paleoindian through the Middle Archaic (Table 7.57). Sample sizes were small, thus not allowing statistical consideration of patterns in either blank selection or standardization. Of the three specimens for which blank types could be identified two were produced from blades, and one was produced from a multidirectional/amorphous blank.

The sample of Unifaces recovered is weighted most heavily toward the Early (Paleoindian) levels (n=40 of 68 total), followed by the Middle (Early Archaic) levels (n=22) (Table 7.58). After the Early Archaic, the use of Unifaces appears to decline in favor of the production of Bifaces, and the expedient production and use of more minimally modified flake implements.

Table 7.57: Blank Types for Perforators (Unifacial Drills) by Period. (Data available in Appendix A, Table A-2.)

	Blade	Multidirectional	Unknown	Total
Zone E		1		1
Zone K			1	1
Zone P	1			1
Zone U	1			1
Total	2	1	1	4

Identifying blank types among the sample of Unifaces was difficult because, unlike the specific uniface categories discussed in the preceding paragraphs, a large proportion of these tools were fragmentary specimens that no longer retained crucial identifying platform characteristics, or enough of the dorsal surface to permit evaluation. These tools may represent fragments of those uniface types discussed above, but their classification into any of the designated categories was impossible, largely due to their fragmentary nature. In some cases, though, blank types were identified. No blank types were recorded for the Type 3 Unifaces, as these specimens received complete dorsal flaking, and likely represented fragments of dorsally

Table 7.58: Blank Types for Uniface Varieties by Period. (Data available in Appendix A, Table A-4.)

Period	Uniface Type	Bld.	Bif.	Multi.	Blk.	Cob.	Bipolar	Unknown	Total
Early	T1	4		1				1	6
	T2			1				7	8
	T3							12	12
	T4							2	2
	Scraper Frags.	1							1
	Unidentified	2		2		2	1	4	11
Middle	T1			1				2	3
	T2	2			1			2	5
	T3							5	5
	T4							1	1
	Scraper Frags.							1	1
	Unidentified					4		3	7
Late A	T1								
	T2		1					1	2
	T3								
	T4								
	Scraper Frags.							2	2
	Unidentified								
Late B	T1	1							1
	T2								
	T3								
	T4								
	Scraper Frags.	1		1					2
	Unidentified							1	1
Total		11	1	6	1	6	1	42	68

Bld. = blade; Bif. = biface; Multi. = multidirectional/amorphous; Blk. = blade-like; Cob. = cobble

flaked End Scrapers. Without dorsal scarring or identifiable platform characteristics, classification of their blank types was impossible. No blank types were identifiable for the Type 4 Unifaces, either.

Among the Type 1 Unifaces, we see a great emphasis on blade use in the Early period. A single specimen produced on a multidirectional blank was also identified from the Paleoindian levels. Only one Early Archaic specimen could be categorized, and it, too, was produced from a multidirectional or amorphous core. A single specimen made from a blade was identified in the Middle Archaic Late B zones.

Few Type 2 Uniface specimens were classifiable according to blank type. A single multidirectional blank was identified from the Early (Paleoindian) levels, 2 blades and 1 blocky specimen from the Middle (Early Archaic) zones, and a biface blank from the Late A (Middle Archaic) levels.

The category of General Unifaces also included a sub-category of Scraper Fragments. Of these implements, only a small number retained characteristics that allowed identification of the blanks from which they were produced. One Early (Paleoindian) specimen was produced on a blade, and the Late B levels produced one specimen made from a blade, and one specimen made from a multidirectional or amorphous core.

Single-edged Type 1 Unifaces, which were recovered from both the Early (Paleoindian) and Mid (Early Archaic) levels, exhibited little standardization of attributes (Tables 7.59, 7.60). Among the Early period specimens, only bit angle displayed high degrees of standardization. Both width and thickness were moderately standardized, but all other attributes were less standardized. Among the Mid period specimens, proximal width was the only attribute to reveal high standardization, but with only two specimens that retained measurable proximal portions,

any apparent patterns are statistically insignificant. With the exception of width, which was moderately standardized in the sample of Type 1 Unifaces from the Mid zones, all other attributes were relatively unstandardized. It appears that these implements were quite variable and were not designed or produced with an emphasis on hafting modifications.

Table 7.59: Standardization in Type I Unifaces, Early Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	6	40.57	12.31	30.34	Low
Width	6	34.49	8.91	25.83	Moderate
Thickness	6	8.68	2.45	28.23	Moderate
Proximal Width	5	32.16	10.51	32.68	Low
Proximal Thickness	5	10.20	4.58	44.90	Unstandardized
Bit Angle	6	65.00	5.70	8.77	Very High

Table 7.60: Standardization in Type I Unifaces, Mid Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	3	55.15	25.22	45.73	Unstandardized
Width	3	29.00	6.03	20.79	Moderate
Thickness	3	10.48	3.40	32.44	Low
Proximal Width	2	22.45	2.57	11.44	High
Proximal Thickness	2	9.55	4.97	52.04	Unstandardized
Bit Angle	2	52.5	0.00	0.00	N/A

The multi-edged Type 2 Unifaces (general unifacial implements with modifications noted along more than one edge), recovered from the Early, Mid, and Late A zones, were similarly variable, with the exception of bit angle measurements, which exhibited high degrees of standardization in all periods (Tables 7.61, 7.62, 7.63). While the high or very high degrees of

standardization in bit angle may be related in part to small sample sizes, it likely also speaks to the importance of specific edge angles for particular functions. Across the four general periods, no differences were noted in mean edge angle, and the degree of variation represented in each time period was consistent (Table 7.64). Results of the D'AD test ($D'AD = 3.40$, $df=2$) showed no difference in CVs among the Early, Mid, and Late A samples. The Late B sample could not be considered in this calculation, as only one Type 2 Uniface was recovered from these levels. The consistency in mean values and in degree of standardization suggests that this attribute may have carried functional significance. Results of the microwear analysis will provide insight into the functions fulfilled by these implements. Other than working edge angle, no other attributes exhibit consistently similar degrees of standardization across time periods.

Among the Early period specimens, thickness was moderately standardized, but all other attributes exhibited low degrees of standardization or were unstandardized. In the Mid period, proximal width and proximal thickness were both moderately standardized, which might suggest that the multi-edged Unifaces from this period were hafted. It is important to remember, though, that the sample sizes from many of the periods are quite low. The patterns that emerge may, therefore, be a function of unrepresentative samples. Width and thickness were unstandardized. In the Late A period, width exhibited very high degrees of standardization, on par with the levels noted for bit angle.

Table 7.61: Standardization in Type II Unifaces, Early Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	8	33.60	14.37	42.77	Unstandardized
Width	8	26.29	10.24	38.95	Low
Thickness	8	7.88	2.30	29.19	Moderate
Proximal Width	1	45.01	N/A	N/A	N/A
Proximal Thickness	1	4.75	N/A	N/A	N/A
Bit Angle	8	65.00	8.66	13.32	High

Table 7.62: Standardization in Type II Unifaces, Mid Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	5	36.82	11.02	29.93	Moderate
Width	5	25.45	8.61	33.83	Low
Thickness	5	9.79	3.79	38.71	Low
Proximal Width	3	16.10	3.89	24.16	Moderate
Proximal Thickness	3	10.04	2.26	22.51	Moderate
Bit Angle	5	59.00	3.79	6.42	Very High

Table 7.63: Standardization in Type II Unifaces, Late A Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	2	52.66	21.06	39.99	Low
Width	2	31.91	1.71	5.36	Very High
Thickness	2	10.34	2.52	24.37	Moderate
Proximal Width	2	35.81	3.85	10.75	High
Proximal Thickness	2	13.44	1.68	12.50	High
Bit Angle	2	61.25	1.77	2.89	Very High

Table 7.64: Results of Kruskal Wallis Test for Bit Angle Mean Values across General Periods. (Primary measurement data available in Appendix A, Table A-4.)

Ranks			
	PERIOD	N	Mean Rank
BIANG	Early	9	10.44
	Mid	5	5.80
	Late A	2	8.25
	Late B	1	13.50
	Total	17	

Test Statistics ^{a,b}	
	BIANG
Chi-Square	3.696
df	3
Asymp. Sig.	.296

a. Kruskal Wallis Test

b. Grouping Variable:
PERIOD

The Type 3 Unifaces likely are proximal (haft) fragments of dorsally flaked end scrapers. All of these specimens were recovered from the Early and Mid zones. The majority of these specimens were recovered as proximal fragments, making any assessment of bit angle standardization and any comparison to the bit angles of the positively identified dorsally flaked End Scrapers impossible. Several attributes of these artifacts exhibit relatively high levels of standardization in both the Early and Mid periods, including thickness, proximal width, and proximal thickness (Tables 7.65, 7.66). Standardization in these characteristics speaks to the apparently great investment in post-detachment modification of the blanks during production of these tools. Much of this modification likely was undertaken to produce haft elements, as indicated by the high standardization of the proximal measurements. Width is highly

standardized in the Early period, but is less standardized in the Mid period specimens, which may reflect either differences in blank choice, or simply the effects of breakage. Length was unstandardized in both the Early and Mid periods, reflecting the fragmentary nature of all of these specimens.

Finally, the category of Type 4 Unifaces comprises fragments of unifacial tools that could not be assigned to any particular category. These specimens are all from the Mid period levels. Only three examples were recorded, making any statistical assessments uninformative. Both length and width were highly variable among these tools, which is unsurprising given the fragmentary nature of these artifacts (Table 7.67). Thickness and bit angle both exhibited moderate degrees of standardization, which may be related to blank selection and function, or may simply be an artifact of the small sample size.

Table 7.65: Standardization in Type III Unifaces, Early Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	11	28.48	9.54	33.5	Low
Width	11	23.94	5.46	22.81	Moderate
Thickness	11	7.53	1.52	20.19	Moderate
Proximal Width	8	14.80	3.97	26.82	Moderate
Proximal Thickness	8	5.46	1.54	28.21	Moderate

Table 7.66: Standardization in Type III Unifaces, Mid Period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	5	34.01	15.23	44.78	Unstandardized
Width	5	23.49	9.18	39.08	Low
Thickness	5	8.27	1.46	17.65	High
Proximal Width	2	11.83	2.12	17.92	High
Proximal Thickness	2	4.98	1.23	24.70	Moderate

Table 7.67: Standardization in Type IV Unifaces, Mid period. (Primary measurement data available in Appendix A, Table A-4.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	3	29.63	17.49	59.03	Intentionally Different
Width	3	14.31	11.69	81.69	Intentionally Different
Thickness	3	6.12	1.43	23.37	Moderate
Bit Angle	3	60.83	12.83	21.09	Moderate

Unifaces: Summary

In addition to the various categories of Scrapers, several other variants of flake tools (Unifaces) were identified. Like the scrapers, most of these specimens were recovered from the Early levels (Paleoindian), with a small sample also having been excavated from the Mid levels (Early Archaic). Some tool categories, when divided by time period, produced such small sample sizes as to be statistically uninformative. With the exception of the Type 3 Unifaces, which likely represent fragmentary specimens of dorsally flaked End Scrapers, the Uniface category comprises generally quite variable specimens.

Across all categories and all time periods, the only attribute that shows consistently higher degrees of standardization is bit angle, which may be related to the particular functional demands of the roles in which these tools were used. The fact that edge angles are so

standardized within the morphological classes that were identified suggests that these morphological categories may also have some basis in function, if we accept that particular edge angles are more or less appropriate for carrying out particular tasks. Most of these angles fell around 60°, which is neither very acute nor very steep. This may reflect their use as general-purpose implements. The remaining attributes are generally quite variable, likely due in large part to the fragmentary nature of the specimens. Also, the inclusion, in the general Uniface category, of flake tool specimens that could not easily be assigned to any of the more specific flake tool classes likely meant that the sub-classes represented a variety of functional types, thus contributing to the variation noted in attributes.

The consistency in proximal thickness measurements noted especially among the Early period End Scrapers is indicative of modification for hafting purposes, likely facilitating the easy replacement of stone bits in standardized haft elements.

Assessing Standardization: Minimally Modified Flake Tools (RFL, RBLD, UFL, UBLD)

Another broad class of flake tools recovered from Dust Cave is the category of minimally modified flakes, which includes Intentionally and Unintentionally Modified Flake and Blade implements (RFL, UFL, RBLD, and UBLD).

The intentionally modified flakes (RFL) are those tools that exhibit purposeful, but minimal, marginal modification in order to alter the edge morphology very slightly. A discussion of intentionally modified blades is included in this section, as they may have served comparable functions, and were modified similarly through the application of very light marginal flaking.

Intentionally Modified Flakes (RFLs) represent one of the most abundant classes of tools recovered from Dust Cave. For the purposes of this study, sample size was reduced by selecting

those specimens that a) could be assigned to a particular or general zone, and b) that had the greatest potential for microwear traces. The chart below records blank types for those specimens that were studied intensively. The sample of blade specimens was much smaller, and nearly all were assignable to a zone, so all Intentionally Modified Blades were considered.

The majority of Intentionally Modified Flakes were recovered from the Early (Paleoindian) levels (n=43 of 80 total), and most of these (n=27) were produced on blades (Table 7.68). Other specimens were made from a wide variety of blank types including blade-like (n=1), blocky (n=6), biface (n=5), multidirectional/amorphous (n=2), and cobble/nodular (n=1). One specimen even appears to have been produced from an exhausted blade core.

By the Mid period (Early Archaic) levels, there is a shift toward much more varied blank use. Of the 21 specimens studied from these levels, we see fairly even representation of blade (n=6), blocky (n=5), and multidirectional/amorphous (n=6) blanks. In addition, some specimens were produced from blade-like blanks (n=2) and biface-derived blanks (n=2).

The Late A and B levels produced relatively few specimens that could be assigned to specific or general zones. Sample sizes from both of these general periods are quite small, but we still see a variety of blank types being used in both periods. Late A specimens included one produced from a blade, two produced from blocky blanks, two produced from multidirectional/amorphous blanks, and one manufactured on a flake derived from a cobble or nodular core. The Late B period specimens also encompass a variety of blank types, including blade (n=2), blocky (n=1), biface (n=2), and multidirectional/amorphous (n=1).

Through time, therefore, blank choice for Intentionally Modified Flake production appears to broaden. While a variety of blank types were utilized in the Early period, blades were emphasized and appear to have been the most commonly utilized blank type for nearly all flake

tool production in the Paleoindian period. By the Early Archaic, though, we see less emphasis on blades compared to other flake types. It appears that toolmakers began to select usable flakes from among a much wider array of choices. This pattern continued through the Middle Archaic at Dust Cave, as well.

Table 7.68: Blank Types for RFL and RBLD by Period. (Data available in Appendix A, Tables A-5 and A-8.)

	Blade	Blade-Like	Blocky	Biface	Multi	Cobble/Nodular	Exhausted Blade Core	TOTAL
Early	27	1	6	5	2	1	1	43
Middle	6	2	5	2	6			21
Late A	1		2		2	1		6
Late B	2		5	2	1			10
TOTAL	36	3	18	9	11	2	1	80

Examination of those specimens produced on flakes other than blades revealed low levels of standardization, or a complete lack of standardization, in all attributes (Tables 7.69, 7.70, 7.71, 7.72). This pattern is apparent through all time periods.

Examination of those tools produced from blades reveals some different patterns in attribute standardization (Table 7.73, 7.74). In the Early period, width was moderately standardized, while all other attributes exhibited low or no standardization. The low CV value for width likely is attributable to the nature of these specialized flakes, which tend to be narrow and more consistent in shape and dimensions. The lack of variation in width may be related to standardization in blade production. The unstandardized nature of the remaining attributes simply reflects the paucity of secondary modification being applied to these tools. It may also signal the selection of slightly “imperfect” blanks. Blade production requires that effort be

expended in the preparation of the core. Because any flake with an appropriate edge can be modified minimally, utilized in an expedient manner as an intentionally modified flake, and discarded almost immediately, it does not seem reasonable to expect that toolmakers were investing significant time or energy in the production of flakes specifically to be used in such a haphazard manner. Blades that were slightly imperfect for the manufacture of more formal tools, or that broke during core reduction, could easily have been conscripted into service as expediently used implements.

Table 7.69. Standardization in Intentionally Modified Flakes, Early Period. (Primary measurement data available in Appendix A, Table A-5.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	48	38.69	16.85	43.55	Unstandardized
Width	48	35.48	13.81	38.92	Low
Thickness	48	11.02	5.27	47.82	Unstandardized
Proximal Width	27	31.28	10.49	33.54	Low
Proximal Thickness	27	11.08	5.21	47.02	Unstandardized

Table 7.70. Standardization in Intentionally Modified Flakes, Mid Period. (Primary measurement data available in Appendix A, Table A-5.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	47	44.84	14.61	32.58	Low
Width	47	36.85	12.96	35.17	Low
Thickness	47	12.93	4.73	36.58	Low
Proximal Width	30	30.55	12.76	41.77	Unstandardized
Proximal Thickness	30	11.46	4.09	35.69	Low

Table 7.71. Standardization in Intentionally Modified Flakes, Late A Period. (Primary measurement data available in Appendix A, Table A-5.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	13	35.72	18.90	52.91	Unstandardized
Width	13	31.25	14.88	47.62	Unstandardized
Thickness	13	12.79	6.05	47.30	Unstandardized
Proximal Width	11	28.76	13.05	45.38	Unstandardized
Proximal Thickness	11	12.01	6.46	53.79	Unstandardized

Table 7.72. Standardization in Intentionally Modified Flakes, Late B Period. (Primary measurement data available in Appendix A, Table A-5.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	16	44.52	15.38	34.55	Low
Width	16	33.93	12.07	35.57	Low
Thickness	16	11.48	4.65	40.51	Unstandardized
Proximal Width	11	29.33	12.47	42.52	Unstandardized
Proximal Thickness	11	10.93	5.47	50.05	Unstandardized

Table 7.73. Standardization in Intentionally Modified Blades, Early Period. (Primary measurement data available in Appendix A, Table A-5.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	23	64.44	29.09	45.14	Unstandardized
Width	23	32.98	7.65	23.20	Moderate
Thickness	23	9.55	4.87	50.99	Unstandardized
Proximal Width	14	25.93	8.96	34.55	Low
Proximal Thickness	14	9.71	4.22	43.46	Unstandardized

Table 7.74 Standardization in Intentionally Modified Blades, Mid Period. (Primary measurement data available in Appendix A, Table A-5.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	2	27.38	1.10	4.02	Very High
Width	2	20.32	0.50	2.46	Very High
Thickness	2	6.11	0.33	5.40	Very High
Proximal Width	1	17.43	N/A	N/A	N/A
Proximal Thickness	1	5.11	N/A	N/A	N/A

The Mid period Intentionally Modified Blade specimens were so few in number that standardization could not be assessed statistically.

Unintentionally Modified Flakes (UFL) are those flakes that were altered only through use rather than through purposeful secondary modification. These tools likely were flakes that were selected and used expediently, and the chipping and flaking seen along their margins represents damage incurred through use, rather than through purposefully applied flaking. Unintentionally Modified Blade tools (UBLD) are included, as these implements may have served a similar function as the flakes selected from the reduction of other core types.

As was the case with the Intentionally Modified Flakes (RFL), the tools presented in Table 7.75 represent a sample of the entire collection of Unintentionally Modified Flake tools recovered from Dust Cave. These are specimens that could be assigned to a particular or general zone and that showed the greatest potential for microwear traces.

Examination of the blank distribution from the Early levels (Paleoindian) reveals a much broader spread of blank types and less of an emphasis on blade flakes. Although 11 specimens were produced from blades, other categories of blanks were well represented, including

multidirectional/amorphous blanks (n=9), blade-like (n=4), blocky (n=4), biface (n=3), and cobble/nodular (n=3).

Table 7.75: Blank Types for UFL and UBLD by Period. (Data available in Appendix A, Tables A-6 and A-8.)

	Blade	Blade-Like	Blocky	Biface	Multi	Cobble/Nodular	Unident.	TOTAL
Early	11	4	4	3	9	3	6	40 (34)
Middle	3	4	8	11	9	2	12	49 (37)
Late A	1	1	2	5	3	1	2	15 (13)
Late B	1		3	2	1		1	8 (7)
TOTAL	16	9	17	21	22	6	21	112 (91)

Unident. = unidentified.

By the Middle period (Early Archaic), the frequency of blades drops and they are replaced by a greater emphasis on biface-derived flakes (n=11). Multidirectional/amorphous flakes (n=9) and blocky flakes (n=8) also figure relatively prominently in the assemblage, followed by blade-like (n=4), blade (n=3), and cobble/nodular (n=2) blanks.

The Late periods produced fewer tools that could be assigned to specific zones or that exhibited good potential for microwear traces, making sample sizes smaller. In spite of the reduced sample size, a similar pattern of varied blank use is apparent in the Late A and Late B (Middle Archaic) periods. Biface-derived flakes were most common in the Late A levels (n=5), while blocky blanks were most common in the Late B sample (n=3).

It seems that tool users were less particular in their selection of blanks for these least modified implements. If these unintentionally modified tools merely were being selected for rapid, immediate, unplanned use, perhaps when the tool user required only a sharp edge to cut something quickly, then any sharp edge would have sufficed, regardless of other flake characteristics. Further consideration of this possibility is given in the following chapter.

Among those specimens produced on non-blade flakes, all attributes were either unstandardized or exhibited very low levels of standardization (Tables 7.76, 7.77, 7.78, 7.79).

This pattern persists through all periods at the cave.

Unintentionally modified blades were recovered from only the Early zone, and most attributes exhibited low degrees of standardization (Table 7.80). The only exception was in tool length, which was moderately standardized. This moderate degree of consistency in length may reflect the standardized nature of blade production, with flakes being removed from a prepared core, or may simply be a fortuitous pattern in the sample. It is doubtful that this pattern has any particular meaning as far as tool design is concerned. The lack of standardization in other attributes speaks to the absence of intentional secondary modification of these blanks, and may again suggest that “imperfect” blades were being selected for use as expedient tools (see argument re: intentionally modified blades, above).

Table 7.76: Standardization in Unintentionally Modified Flakes, Early Period. (Primary measurement data available in Appendix A, Table A-6.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	55	46.63	15.12	32.43	Low
Width	55	39.01	15.85	40.63	Unstandardized
Thickness	55	10.87	5.92	54.46	Unstandardized
Proximal Width	42	30.15	11.59	38.44	Low
Proximal Thickness	42	10.82	5.20	48.06	Unstandardized

Table 7.77: Standardization in Unintentionally Modified Flakes, Mid Period. (Primary measurement data available in Appendix A, Table A-6.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	90	39.28	14.00	35.64	Low
Width	90	31.53	10.81	34.28	Low
Thickness	90	8.21	4.54	55.30	Unstandardized
Proximal Width	72	25.76	9.55	37.07	Low
Proximal Thickness	72	8.16	3.90	47.79	Unstandardized

Table 7.78: Standardization in Unintentionally Modified Flakes, Late A Period. (Primary measurement data available in Appendix A, Table A-6.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	82	41.34	12.40	30.00	Low
Width	82	33.95	12.20	35.94	Low
Thickness	82	8.60	4.22	49.07	Unstandardized
Proximal Width	71	25.36	9.18	36.20	Low
Proximal Thickness	71	8.70	4.60	52.87	Unstandardized

Table 7.79: Standardization in Unintentionally Modified Flakes, Late B Period. (Primary measurement data available in Appendix A, Table A-6.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	70	47.20	16.19	34.30	Low
Width	70	36.09	11.32	31.37	Low
Thickness	70	9.37	5.08	54.22	Unstandardized
Proximal Width	57	30.22	11.88	39.31	Low
Proximal Thickness	56	9.84	5.17	52.54	Unstandardized

Table 7.80: Standardization in Unintentionally Modified Blades, Early Period. (Primary measurement data available in Appendix A, Table A-6.)

Attribute	Frequency	Mean	Standard Deviation	Coefficient of Variation (%)	Degree of Standardization
Length	10	65.62	16.63	25.34	Moderate
Width	10	31.04	9.99	32.18	Low
Thickness	10	7.03	2.23	31.72	Low
Proximal Width	8	22.08	7.26	32.88	Low
Proximal Thickness	8	7.91	2.43	30.72	Low

Minimally Modified Flakes: Summary

Most Intentionally Modified Flakes were recovered from the Early levels, and the majority of these were produced from blades. Blocky and biface-derived specimens were next most common in the Early period sample, with only a few multidirectional, cobble, and blade-like blanks represented. By the Mid period, much more varied blank selection was noted. Blade, blocky, and amorphous/multidirectional blanks were represented nearly equally in the sample. Among those specimens that were assigned to the Late A and Late B periods, few blank types could be identified. My expectation was that biface blanks would have been used more frequently in the later period, in response to the increased use of bifaces over formal flake tools at this time. In light of difficulties in classifying many of the later specimens into blank type categories, though, this possibility was difficult to assess.

Among the Unintentionally Modified Flake tools, less emphasis was noted on the use of blades in the Early period compared to other blank types. Blades are still relatively common in the Early sample but were used in similar frequencies to multidirectional blanks. Lesser, but fairly even proportions of blade-like, blocky, biface, and cobble blanks were also noted. By the

Mid period, biface-derived blanks had become more common than blades. Amorphous or multidirectional and blocky blanks were also fairly common. Blades, blade-like flakes, and cobble blanks were recovered in much smaller proportions. While sample sizes were small in the Late A and Late B periods, simply because of my inability to assign specimens to particular zones or levels, some trends were apparent. Biface-derived blanks were most common in the Late A sample, while blocky blanks were most common in the Late B sample.

Little standardization is noted in any of the subclasses of minimally modified flakes from any time period. Exceptions are noted in the width of intentionally modified blades (RBLD), which exhibit fairly high degrees of standardization as a result of the nature of blade core preparation and blade production. Standardization in the length of unintentionally modified blades (UBLD) may also be explained with reference to the standardized nature of core production. Many blades could have been removed from a single core, and the height of this core (corresponding to the length of the unretouched blade) would have remained fairly consistent throughout reduction.

Summary of Tool Production: Blank Manufacture and Artifact Standardization

While small sample sizes made it difficult to identify patterns in some tool classes, certain basic trends in both blank manufacture and artifact standardization can be identified. Blank selection could not be evaluated for the stage bifaces, or for the bifacial drills, because flake characteristics were removed during the production process, which involved bifacial flaking of the original blank.

Across all periods, 154 artifacts could be assigned with fair certainty to a blank type category (Table 7.81). The remaining artifacts could not be assigned to a blank category as a

result of blank characteristics being obliterated by breakage, use, or post-detachment modification, or because of the ambiguity of characteristics on particular specimens. Examination of the data from all periods shows a clear emphasis on blades (44.16%, n=68), followed by multidirectional/amorphous (19.48%, n=30), and blocky (16.23%, n=25). The remainder of the sample comprised similarly low representations of biface (9.09%, n=14), cobble (7.14%, n=11), and blade-like (3.90%, n=6) blanks. It is conceivable that the biface, multidirectional/amorphous, and blade-like flakes are all, in fact, the products of biface core reduction, in which case biface flakes would be the second most common blank type in the assemblage (32.47%, n=50).

The proportions and frequencies discussed above may be somewhat misleading for two reasons. First, blades are a peculiar flake type, with readily identifiable characteristics that are less easily confused with other blanks. They may, therefore, be over-represented simply because of the ease with which they may be identified. Second, the apparent dominance of blades in the assemblage may be a function of the history of excavation at the site. Interpretation of the stratigraphy was an ongoing process. As such, many of the artifacts from the shallower levels, which were encountered earlier in the excavations, could not immediately be assigned to particular zones that were identified and designated in later excavation seasons. While later period artifacts, from stratigraphically higher levels, had excavation depths recorded for them, associating these depths with a zone remained problematic for particular units. In some cases, they could be assigned to a general “Late” period, and in other cases the association was too tenuous. It is clear that more bifaces were being utilized in later periods, relative to the formal unifaces that were seen with greater frequency in the earlier zones, and fewer blades were expected and recorded for these later periods. The overwhelming emphasis on blade use in the

overall sample may, therefore, simply reflect their representation in a better-understood period of occupation, and better-documented series of strata.

Table 7.81: Frequency of Blank Types by General Period. (Data available in Appendix A.)

Period	BLD	BIF	AMO/ MULTI	BLK	BLL	COB	Total	%
Early	52	8	14	10	4	6	94	61.03
Mid	10	3	11	8	2	4	38	24.68
Late A	2	1	3	2	0	1	9	5.84
Late B	4	2	2	5	0	0	13	8.44
Total	68	14	30	25	6	11	154	100.00
%	44.16	9.09	19.48	16.23	3.90	7.14	100.00	

BLD = Blade; BIF = Biface; AMO/MULTI = Amorphous/Multidirectional; BLK = Blocky; BLL = Blade-like; COB = Cobble.

If we consider blank representation by general period, the trends noted above (i.e., more emphasis on blades in earlier periods, and more emphasis on bifaces in later periods) are reinforced. Table 7.82, below, presents overall blank frequencies and proportions by general period. From these data, we see that blades are most common during the Early period of occupation. Their representation decreases by nearly half in the Mid period and is halved again by the Late A period. While there is an apparent increase in blade use by the Late B period, this pattern likely is a reflection of the small sample size from this zone. In contrast, a gradual increase in biface blank representation is noted through time. However, this increase in biface-derived flakes is much less dramatic than is the decrease in blade representation, suggesting that bifaces and their by-products were used much more commonly through all periods.

Amorphous/Multidirectional blanks exhibited a relatively dramatic increase in proportion from the Early to the Mid period, followed by a more gradual increase from the Mid to Late A period.

Their representation diminished from the Late A to Late B period, again likely influenced by the small sample size from the latest period of occupation. Blocky and cobble blanks increased steadily, although not dramatically, through time, while blade-like flakes maintained low frequencies and proportions in all periods. What these patterns suggest is that toolmakers began to make use of a wider variety of blank types in the production of at least certain tool classes. They placed less emphasis on the specialized production of blanks (i.e., blades) and relied more often on flakes that likely were fortuitous by-products of the manufacture of other implements (e.g., biface blanks).

Table 7.82: Blank Types by General Period. (Data Available in Appendix A.)

Blank Type	Early	Mid	Late A	Late B
Biface	8 (8.5%)	3 (7.9%)	1 (12.5%)	2 (15.4%)
Blade	52 (55.3%)	10 (26.3%)	1 (12.5%)	4 (30.8%)
Blade-Like	4 (4.3%)	2 (5.3%)	0 (0%)	0 (0%)
Blocky	10 (10.6%)	8 (21.1%)	2 (25.0%)	5 (38.5%)
Cobble	6 (6.4%)	4 (10.5%)	1 (12.5%)	0 (0%)
Multi./ Amorph.	14 (14.9%)	11 (28.9%)	3 (37.5%)	2 (15.4%)
Total	94 (100%)	38 (100%)	8 (100%)	13 (100%)

Blank selection was much easier to consider among some of the flake tool classes. Overall, blank selection among the Scrapers was somewhat varied, with blade use being represented best among the End and Side Scrapers. While blades were common in this tool class, they were not used exclusively, as other flake types were also represented. It appears that the specimens produced on blades received less modification in order to achieve the desired tool form than did other blank types.

No patterning in blank selection was identifiable in the sample of either Gravers or Perforators, as samples were too small. Within the category of General Unifaces some patterns were recognized, although this general category included many fragmentary specimens for which blank identification was impossible. This was true especially for the Type 4 Uniface specimens and the category of unidentified General Unifaces. No blank types were identifiable for the Type 3 Unifaces, either, in part because of the fragmentary nature of these specimens and in part because of the complete dorsal flaking applied to these items, which obliterated flake blank characteristics. Among the Type 1 Unifaces, blade use was common in the Early and Mid periods. Few blank types were identifiable for the Type 2 Unifaces. Of those that could be interpreted, no particular patterning was evident. Blank selection was, instead, quite variable.

Blank selection patterns could be identified for the minimally modified flake tools, which included Intentionally and Unintentionally Modified Flakes and Blades. Among the Intentionally Modified Flakes, blade use dominated the specimens from the Early period levels. Blocky and biface-derived specimens were the next most common categories in the Early period. A few multidirectional/amorphous, cobble, and blade-like specimens were also identified, although these were significantly less common. By the Mid period, blank selection was much more variable, with blade, blocky, and multidirectional/amorphous blanks being represented nearly equally in the sample. In the Late A and Late B periods, few specimens could be assigned to a blank type category. Among the few tools for which blank type could be identified it was apparent that blank selection was relatively varied. My initial expectation was that biface blanks should be seen in greater numbers in the later periods because of increased use of bifaces over formal flake tools at this time.

Among the Unintentionally Modified Flakes, blade use was not as strongly emphasized in the Early period. Instead, a wider variety of blank types were represented, including blades and multidirectional/amorphous flakes. Fairly even, although lesser, proportions of blade-like, blocky, biface, and cobble blanks were also represented. Fewer blades were noted in the Mid period sample, with biface blanks becoming more common. Multidirectional/amorphous and blocky blanks were also relatively common. A smaller number of blade-like and cobble flakes, as well as blades, were noted. By the Late A and Late B periods, few specimens could be assigned to blank categories. Of the few specimens that were identified, biface blanks were most common in the Late A levels, and blocky blanks were most common in the Late B levels.

An assessment of tool and blank standardization revealed several patterns in the various artifact categories. Stage Bifaces became progressively less standardized throughout the reduction sequence, a pattern that persisted through time. No patterns could be discerned in the small sample of bifacial Drills. Among the flake tools, the greatest degrees of standardization were seen among the Scrapers, especially End Scrapers and Side Scrapers, including those made on blades. Much less standardization was seen in other Uniface types, even among the Intentionally and Unintentionally Modified flakes that were produced from blades.

Certain attributes more consistently exhibited higher levels of standardization across artifact classes. Among many of the Uniface classes, especially the Scrapers, bit angle was highly standardized, perhaps reflecting either functional requirements as a dominant design consideration or unintentional edge angle changes through resharpening. Proximal dimensions were also highly standardized within the category of End Scrapers, suggesting that hafting ability was a primary concern in the design of these implements. The high degree of standardization also suggests re-use of hafts, with standardized bits likely being more easily replaceable, perhaps

under conditions of intensive periods of use, or time stress in the performance of particular tasks. No hafting modifications were apparent among any of the other flake tool classes, including the other Scraper sub-classes. While Humpback Scrapers were stemmed, their proximal measurements did not exhibit any degree of standardization, suggesting that standardized hafts were not used with these tools.

It is difficult to evaluate changes over time in patterns of standardization, as the Scrapers and Blades, which are the categories in which we see the greatest degrees of standardization, are restricted primarily to the Early period. These formal unifaces essentially disappear by the later levels. While it is difficult to say anything about levels of standardization within certain tool classes, I can say that the declining emphasis on formal flake tool technology throughout the sequence necessarily implied reduction in standardization over time in the flake technology in general.

In the following section, patterns of tool discard are evaluated. In concert with a consideration of the emphasis on standardization, an evaluation of discard patterns allows us to approach an understanding of particular issues in tool design. Higher degrees of standardization are often reflective of a need for raw material economy, a desire to produce tools that will continue to function under particularly demanding use conditions, or when activities are carried out at locations far removed from preferred raw material sources. Standardization of implements is often interpreted as a means of ensuring that tools can be utilized and resharpened repeatedly, and can be reworked into other tool forms if they become damaged. By reducing the potential for tool failure, and the corresponding failure to accomplish a task successfully, standardization of tools may, therefore, be argued to have an impact on individual or group survival. By considering breakage patterns, we can ask at what point in the use lives of implements these

artifacts were being discarded. Were they abandoned after prolonged periods of use and reuse, or after immediate and short-term use? Were they discarded only when the potential for tool failure was high, and the consequences of corresponding task failure were high, or were they discarded only if they were broken or no longer retained any utility?

Below is a discussion of the condition in which artifacts were recovered, which may indicate the condition of the artifact upon discard (i.e., as it entered the archaeological record), or the nature of post-depositional alterations made to the artifact (i.e., after the artifact entered the archaeological record). Condition upon discard can provide insight into several important issues, including: raw material economy; the position of Dust Cave in the technological cycle; whether activities represented by the tools were being carried out on-site, or whether tools were being produced in advance of use elsewhere; and patterns of site use, including what activities were being carried out at Dust Cave at different periods of time, and what type of site Dust Cave represented (e.g., residential locale, specialized resource extraction camp, retooling station, etc.). Discard patterns, in association with a consideration of the degree of artifact standardization, may, therefore, provide insight into how tools were designed to fit into the hunter-gatherer lifestyle and how their design facilitated the confrontation of various adaptive challenges, including: how to make raw materials available at tool use locations away from the raw material source; how to ensure that toolkits are in usable condition in order to take advantage of periodicity in resource availability (e.g., seasonal fluctuations in resources); how to ensure that technological pursuits do not interfere with the ability to carry out subsistence pursuits or to encounter other populations for social exchanges; etc. These adaptive challenges will condition the design of tools and technological strategies but will also determine when, and in what condition, tools were discarded. Were tools used to exhaustion, after multiple episodes of use

and resharpening, or were they discarded immediately after they became dulled or damaged? Were broken implements recycled into other tool forms or were they abandoned in favor of new replacement parts? Were tools discarded with plenty of utility remaining, perhaps before their potential for failure at critical moments became too high, or were they discarded only after maximum utility had been extracted from them? These questions are considered below.

TOOL CONDITION UPON DISCARD

The previous section presented a discussion of some of the design decisions that were made in the production of stone tools from Dust Cave, namely the core types employed, and the relative emphasis on standardization in tool production in various classes through time. Here, patterns of tool utility are discussed. In particular, this section considers the point at which tools were no longer deemed to be useful and were therefore discarded. An evaluation of tool condition upon discard, as the tool entered the archaeological record, is fundamental to developing an understanding of technological organization, as it provides important insights into perceptions of tool utility, anticipation of technological needs, patterns of manufacture, and site functions.

Tools may enter the archaeological record through several possible channels. A tool might simply have been lost accidentally, as in the case of a projectile tip falling out of a bag or other container during the course of a hunting expedition. Alternatively, a tool might have been used on a site and discarded either when it broke or when the user determined that no further utility could be or needed to be extracted from the implement. Another possibility is that tools might have been used throughout the settlement-subsistence-technological cycle, being curated until toolmakers arrived at a site where the toolkit could be replenished. In this case, tools could

have been transported, used to the point of exhaustion (or until the risk of tool failure was deemed too high), and discarded at the point where retooling occurred. This list of possible discard scenarios is not exhaustive, by any means, but provides a sense of the range of possible avenues through which implements may enter the archaeological record.

Tools that are lost, as opposed to being discarded purposefully, are more difficult to identify as having been “lost” when they are recovered in other than isolated contexts. A projectile tip that is lost during a hunting foray and recovered in isolation is more easily classified as representing an accidental loss than is a tool that was dropped and forgotten during use at a site where other tools were being utilized and discarded. Lost tools would tend to be complete or relatively complete, perhaps showing signs of use and rejuvenation. Such tools found on-site might be difficult to distinguish from implements that were cached at the site or that were abandoned after reaching the end of their perceived use lives.

In evaluating the circumstances surrounding the discard of tools that were used on-site, it is helpful to draw a distinction between formal implements and more expediently produced tools. Expedient items, such as Intentionally and Unintentionally Modified Flake tools, are simple to produce and require virtually no investment of time or energy in their production. In the case of expedient tool use, a suitable flake can be selected and used briefly as a general-purpose cutting implement. Such a flake might be produced intentionally for the purpose of immediate and brief use, or might be scavenged from the debris of an earlier knapping episode. These are not tools intended for transport and maintenance over time. When simple flake tools were being used on-site, it is reasonable to expect that they were being produced more expediently from locally available materials, including local chert deposits and transported cores that may have been carried in from elsewhere. The identification of expedient flake tools on a site, therefore, can be

interpreted as being representative of activities that were actually occurring on-site. While the very generalized techno-morphological characteristics of these simple flake tools are not very informative regarding their function, we can turn to functional (microscopic use wear) analysis to understand the range of tasks in which these implements were being used. The results of my functional analyses are discussed in the following chapter.

Formal tools, on the other hand, are more likely to have been “curated” implements, and may have been transported and carefully tended by the tool-user. These implements more frequently exhibit evidence for repeated resharpening, reworking, and reuse (e.g., changes to working edge morphology such as steeper edge angle, edge serration, edge beveling, blade narrowing, etc.). These artifacts tend to exhibit more specialized morphologies and were altered quite intentionally.

Formal implements are more likely than expedient flake tools to have been used and abandoned or discarded at sites that were removed from their locations of manufacture. The presence of more formal tools in an assemblage may be explained in any one of several ways. First, a formal tool could have been lost accidentally, in which case we might expect to see an intact implement with some utility remaining, barring the case of post-depositional breakage. On a site where so many tools were recovered, though, this possibility is difficult to assess, as intact implements may have been discarded for other reasons as well. Second, a formal tool could have been discarded as a result of breakage during manufacture. If the site served as a “retooling” station, where exhausted toolkits were replenished, we would expect to see discarded tools or tool fragments that show characteristic manufacturing errors (e.g., failures to thin, edge collapse, etc.), and no evidence for use. Some fragments of appropriate sizes or shapes may have been salvaged for transformation into a different tool type (e.g., haft ends of projectile tips could have

been reworked into hafted end scrapers). A third possibility is that the tool was discarded after being used to the point of exhaustion, either on-site or at sites elsewhere on the landscape, before being discarded at the retooling locale. Exhausted tools will exhibit characteristics of use and resharpening, as well as evidence for greater degrees of exhaustion. These traces differ according to tool type and may include alterations to the working edge morphology or angle, reduction of tool length, etc. The particular changes we would expect to see will be outlined in the discussions of specific artifact classes. Because tools are easier to manufacture than are the hafts (Keeley 1982: 800), tool users may have returned the hafts to the retooling site, with broken proximal fragments still attached, in which case we might expect to see broken haft/proximal elements being discarded.

Below, patterns of discard are considered, with reference to tool breakage and condition, including degrees of exhaustion, among the tool classes from the various occupation periods represented at Dust Cave.

Tool Condition: General Observations

Tools were examined for their condition upon recovery and were classified as being complete, relatively complete, or fragmentary. Fragmentary specimens were further classified into categories according to the portion of the tool that was recovered (proximal, distal, medial, lateral, or surface fragments, or any combination thereof). Among certain tool classes, fragment types were difficult to assess because these implements did not retain characteristics that allowed the tool segment to be oriented. For example, some specimens did not exhibit identifiable ventral flake surface characteristics, while others were not manufactured in such a way as to produce an outline shape with a distinct proximal and distal end. This is true of many bifaces from earlier in

the manufacturing sequence, specifically Early Stage Bifaces and Mid Stage Bifaces. While some of these tools may have been produced on large flake blanks, others would have been reduced bifacially from large, unflaked pieces of raw material so that no proximal or distal flake end was evident. Of those that were produced from flake blanks, many had their original flake characteristics removed through the process of reduction. Also, many of these implements were discarded early enough in the reduction sequence that they had not yet taken on the distinct outline morphology that would characterize their final forms. It is difficult, therefore, to categorize these pieces as representing proximal or distal fragments. Medial and some lateral fragments are sometimes easier to identify because classification of these fragments is less dependent on being able to recognize a proximal or distal portion. For these unclassifiable biface fragments break direction (e.g., transverse, longitudinal, etc.) was recorded, rather than tool portion. Later stage bifaces, on the other hand, were easier to orient as they tended to exhibit a pointed distal end and a straight, rounded, or squared proximal end.

Condition of the Hafted Bifaces and Probable Hafted Bifaces was not recorded because their condition was implied by their classification into these two categories. Those items identified as Hafted Bifaces were, by definition, complete or relatively complete, retaining enough of the haft and blade element to allow identification and association with a temporal-cultural category. All Probable Hafted Bifaces, on the other hand, were fragmentary. They are pieces that likely were segments of Hafted Bifaces and were classified as such based on retention of apparent hafting features at the proximal end (e.g., a segment of a notch or shoulder, or a portion of a basal ear remaining). These tools were fragmentary enough, though, that I was unable to classify them into a specific temporal-cultural category.

This section also presents a discussion of the condition of expediently produced and utilized flake tools, specifically the Intentionally Modified Flakes (RFL) and Unintentionally Modified Flakes (UFL). The condition of these implements is less crucial to our understandings of technological organization than is the condition of more formal tools, because we can be fairly certain that these items were being used on the site, rather than being manufactured for transport and use elsewhere. Because Intentionally and Unintentionally Modified Flake tools were produced, used, and discarded almost immediately, their condition upon discard is less informative regarding broader patterns of technological organization. Any broken implements were simply damaged during use on the site, rather than representing tools that were discarded in preparation for toolkit rejuvenation. In addition, certain broken specimens may represent flake *fragments* that were repurposed into expedient tools (i.e., the blank itself was broken rather than the tool being broken during manufacture, during use, or post-discard). Complete specimens, on the other hand, may have represented newly manufactured items, or items that survived unscathed through the brief episode of use. Understanding the condition of these items, therefore, is relatively uninformative about patterns of technological organization. However, their presence on the site may reveal important insights into the nature of immediate and anticipated tool use, and will shed light on the technological position of Dust Cave in the settlement-subsistence cycle. Data regarding the condition of these expedient tools are presented, focused only on those specimens that were examined in detail as part of my microwear study.

The remainder of tool classes are discussed in detail, as it was possible to orient these other implements, which may provide insight into the circumstances under which tools were being discarded.

Tool Condition: Early Levels (Paleoindian Zones T, U, S2)

The Paleoindian levels produced a total of 45 complete, 41 relatively complete, and 166 fragmentary specimens, as well as 7 for which condition was indeterminate (Table 7.83). The majority of tools from these earliest levels are fragmentary (64% of the assemblage), but this pattern does not hold across all individual tool classes.

Across the various stage biface categories, fragmentary specimens were more common than were complete/relatively complete specimens. The single Early Stage Biface recovered from the Paleoindian zones was fragmentary, and a larger number of fragmentary Mid Stage Bifaces was recorded than complete/relatively complete specimens. The Early Stage Biface fragment was a lateral (edge) fragment, while nearly all the Mid Stage Biface fragments (n=5) were broken transversely, meaning that they were snapped across the width of the tool into tip and basal portions. Two of the Mid Stage Bifaces, including one of the transversely snapped fragments, exhibited thermal damage. A single longitudinal/lateral Mid Stage Biface fragment was also recorded. Fragmentary specimens were much more common among the later stage Trimmed Biface I and II categories, than were complete/relatively complete examples. The break types among the Trimmed Biface I and Trimmed Biface II categories were more variable. The majority of Trimmed Biface I fragments were proximal fragments (n=7). Four medial fragments were recorded, as well as two distal pieces. Among the Trimmed Biface II specimens, the most common fragments were distal or tip fragments (n=14). Proximal, or basal, fragments were next most common (n=10), followed closely by medial fragments (n=8). Only 1 lateral segment was recovered. Of the several bifacial drills found, all were fragmentary. Most of these were distal fragments (n=4), although one medial fragment was also recorded.

Scrapers exhibited relatively equivalent proportions of complete/relatively complete and fragmentary specimens, with a slight bias noted toward the complete/relatively complete examples. End Scrapers exhibited similar frequencies of complete/relatively complete and fragmentary specimens, as well as similar frequencies of proximal (n=2) and distal (n=3) fragments. Side Scrapers and Ovoid Scrapers, on the other hand, were more often complete or relatively complete than fragmentary. The fragmentary Side Scraper specimens included 1 distal and 2 proximal fragments, while the single Ovoid Scraper fragment was a lateral piece. The single Humpback Scraper recovered was complete.

Most of the general Unifaces recorded were broken portions, with fragments far outnumbering complete/relatively complete specimens. The vast majority of these fragments were proximal pieces (n=15). In addition to these, 3 distal and 2 lateral fragments were recovered. Gravers, on the other hand, showed a higher proportion of complete than fragmentary specimens, although the margin was not great, given the small sample size. Of the two fragmentary pieces, one was a proximal fragment and the other a fragment.

Among the expediently produced flake tools, many more fragments were recorded within the Intentionally Modified Flake (RFL) category, while the opposite pattern prevailed among the Unintentionally Modified Flake tools (UFL; i.e., more complete/relatively complete specimens). Break types among these categories are varied, and did not exhibit any particular patterning. Adding to the confusion in discerning any patterning in condition upon discard is the fact that it can be difficult to determine whether these simple flake tools were broken during use, or whether they were flake fragments that were enlisted for use as expedient tools. It is only when secondary flaking or incidental use damage crosses the break facet that we may discern the nature of the breaks. Without secondary flaking, no such distinction can be made.

Table 7.83: Tool Condition, Early Period zones. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragment	Unknown
ESB (n=1)	0	0	1	0
MSB (n=10)	1	2	7	0
TBI (n=18)	1	4	13	0
TBII (n=36)	4	0	32	0
DRL (n=5)	0	0	5	0
ESCR (n=10)	3	2	5	0
SSCR (n=8)	3	2	3	0
OSCR (n=8)	4	3	1	0
HSCR (n=1)	1	0	0	0
UNF (n=37)	4	3	29	1
GRV (n=6)	4	0	2	0
RFL (n=41)	5	1	29	6
UFL (n=89)	5	13	15	0
BLD (n=8)*	1	1	0	0
RBLD (n=23)	7	5	11	0
UBLD (n=10)	3	3	4	0
BSCR (n=14)	3	2	9	0

ESB = Early Stage Biface; MSB = Mid Stage Biface; TBI = Trimmed Biface I; TBII = Trimmed Biface II; DRL = Drill; ESCR = End Scraper; SSCR = Side Scraper; OSCR = Ovoid Scraper; HSCR = Humpback Scraper; UNF = General Uniface; GRV = Graver; RFL = Intentionally Modified Flake; UFL = Unintentionally Modified Flake; BLD = Unmodified Blade; RBLD = Intentionally Modified Blade; UBLD = Unintentionally Modified Blade; BSCR = Blade Scraper (*indicates remaining specimens were not located in the collection)

Finally, the general category of blade tools produced fairly even representation of fragmentary and complete/relatively complete specimens except among the Blade Scraper category, in which fragments were more common. Intentionally Modified Blade fragments included fairly even numbers of distal (n=4) and medial (n=5) fragments, as well as two proximal fragments. The Unintentionally Modified Blade fragments were evenly divided between proximal (n=2) and medial (n=2) segments. The majority of the Blade Scraper fragments were distal portions (n=6), although proximal (n=2) and medial (n=1) fragments were also recovered.

General Early Levels

The sample of tools from the general Early Levels is smaller than that attributed to the specific Paleoindian zones, but many patterns seen in the specific zones are mirrored in the general assemblage. The general zones produced a total of 9 complete, 9 relatively complete, and 43 fragmentary specimens, as well as 3 with unidentified types of damage (Table 7.84). As was the case with the sample from the specific zones, the majority of implements from the general zones are fragmentary (67%).

While a narrower range of tools is seen in the general Early levels, compared to the specific Paleoindian zones, certain tool patterns are the same. As with the Mid Stage Bifaces recovered from the specific Paleoindian zones, those fragmentary specimens from the general Early Levels were broken transversely. Among the late stage Trimmed Biface I and Trimmed Biface II categories, far more fragments were recorded than complete/relatively complete specimens. The majority of broken Trimmed Biface I specimens are represented by medial fragments (n=6). Four proximal fragments and two distal fragments were also recorded. Among the Trimmed Biface II fragments, most were distal pieces (n=7), with lateral (n=2), proximal (n=2), and medial fragments (n=1) comprising smaller portions of the sample.

Patterns in the other tool classes are not quite as distinct, simply because of the small sample sizes. Overall, though, we tend to see more complete/relatively complete specimens among the various scraper types, fairly even numbers of complete/relatively complete and fragmentary specimens of Intentionally Modified Flake tools, and a larger number of fragmentary blades. Of the fragmentary End Scraper specimens that were recovered, two were lateral fragments, and one was a distal fragment. Of the three fragmentary general unifaces specimens in the sample, I

recorded one proximal, one distal, and one lateral fragment. The Intentionally Modified Flake tools include a wide variety of fragment categories. The categories of Intentionally and Unintentionally Modified Blade tools are represented by only a single distal fragment each, while the single Blade Scraper is a proximal fragment.

Table 7.84: Tool Condition, General Early Levels. (Data Available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
Mid Stage Biface (MSB)	0	0	3	0
Trimmed Biface I (TBI)	0	2	12	0
Trimmed Biface II (TBII)	1	1	12	0
End Scraper (ESCR)	3	3	3	0
Humpback Scraper (HSCR)	1	0	0	0
Ovoid Scraper (OSCR)	1	0	0	0
General Uniface (UNF)	0	1	3	1
Intentionally Modified Flake (RFL)	3	2	7	2
Blade Scraper (BSCR)	0	0	1	0
Intentionally Modified Blade (RBLD)	0	0	1	0
Unintentionally Modified Blade (UBLD)	0	0	1	0

Discussion: Early Levels

The fragmentary specimens seen among the earliest of the stage bifaces (ESB, MSB) likely represent specimens broken during manufacture or reduction rather than use. In examining these tools during the initial stages of the stepwise selection process for use wear sample selection, no evidence was detected to suggest that these implements had been used (see Chapter 8). Instead, the transverse breaks and longitudinal breaks likely represent snaps and edge collapse during the reduction of large pieces of raw material into these early stage bifaces.

Examination of the Trimmed Biface specimens showed more proximal fragments in the Trimmed Biface I category and more distal or tip fragments in the Trimmed Biface II category. This division may be somewhat artificial, as the distinction between Trimmed Biface I and Trimmed Biface II specimens rests on the number of marginal flake scars per unit of edge length. To produce the more refined and highly shaped tips of these specimens may have required the application of greater amounts of secondary modification than would have been necessary for creating the less refined morphology of the proximal ends. In this case, we might expect more flake scars at the distal end than at the proximal end. The apparent division between the greater frequency of *proximal* Trimmed Biface I fragments and *distal* Trimmed Biface II fragments may, instead, be an artifact of differences in the degree of post-detachment modification applied to the proximal and distal ends of implements that may have been regarded as being the same class by their makers.

The lack of proximal modifications such as notches or stems on these specimens suggests that the Trimmed Bifaces (I and II) were not hafted implements. As such, there is no reason to expect that proximal fragments would represent haft portions being returned to the site, in their hafts, for retooling. Instead, it is likely that these fragments simply represent portions of tools broken either during manufacture or use on-site. It is possible that these specimens represent implements that were produced at Dust Cave for transport and use elsewhere, and that they were broken during manufacture. Lack of evidence for use, discussed in the following chapter, along with the prevalence of transverse snaps, suggests breakage during manufacture rather than during use as unhafted bifaces (e.g., handheld knives).

The high frequency of distal fragments among the Drill specimens likely reflects breakage of those tools during use at the site. The long and narrow tips would have been

susceptible to breakage, and it is unlikely that tool users would have transported these fragments from sites elsewhere in the region to be deposited at Dust Cave. Proximal fragments, on the other hand, might have been transported, as these implements appear to have been hafted. Production of hafts requires greater effort than does production of stone tools, meaning that hafts are likely to have been returned to the site for reuse at the location where new tools were manufactured and/or rehafted. If the drills were used off-site, then these hafts may have been returned to the site with broken proximal portions still embedded. These proximal fragments could also have been reused as Drills, if tips were reshaped, or could have been transformed into another type of hafted implement, in the case of those with particularly elongated haft portions.

While fragments are relatively common among the Scraper specimens, many complete or relatively complete examples were also noted. The frequent appearance of complete/relatively complete examples may suggest the use of tools on-site, or the discard of previously used tools at a site used at least in part as a retooling station. It is assumed, and confirmed by microwear analysis in the following chapter, that End Scrapers were being used to remove hair and tissue from animal hides. The paucity of deer bones in the occupation deposits at Dust Cave might suggest, upon first consideration, that much of the processing was occurring off-site. This pattern, in concert with the frequency of complete and utilized End Scraper specimens, could be interpreted as indicating that these tools were being returned to the site for toolkit replenishment. As discussed earlier in this chapter, production of hafts is more labor-intensive than is production of stone bits. Tool users may, therefore, have been returning hafts to the site for the purpose of retooling, with utilized and potentially exhausted bits still embedded. Exhausted Scrapers could have been discarded, and new Scrapers produced and inserted into these curated hafts. Walker's (1998) analysis of the skeletal elements that were represented in the deer sample, however, paints

a different picture. She notes that less valuable elements, including crania, limbs, and vertebrae, were most commonly recovered, suggesting that the valuable portions of meat were being removed from Dust Cave after primary processing. Scrapers, which appear to have been used to process dry hides (see Chapter 8) may, therefore, have been used and discarded on-site as part of a somewhat extended period of site use for the purpose of hunting, gathering, processing, and tool maintenance and manufacture. This possibility and its ramifications for understanding behavioral patterns during the early use of the site will be discussed in greater detail in the concluding chapter (Chapter 9). These implements, which were hafted, likely were discarded in the course of retooling. Rather than representing a portion of the toolkit used while away from the site, though, these implements may have been used, discarded, and replaced while at Dust Cave.

As well as the complete/relatively complete specimens, several fragmentary End Scrapers were also recovered. If these were fragments of tools that had been broken during manufacture, we would expect no evidence for use. If, on the other hand, these were fragments of utilized implements we would expect to see some evidence of these tools having been used. These traces of use could include changes in the bit angle and degree of bit convexity, rounding of the bit margin, as well as a suite of changes at the microscopic level, which are discussed in the following chapter.

The remaining scraper specimens, including Side, Ovoid, and Humpback Scrapers, were more often recovered as complete/relatively complete items than as fragments. Their condition suggests either that they were being brought back to the site intact, likely after use elsewhere, or that they were being used on-site and discarded at some point prior to breaking. A consideration of their degree of exhaustion may aid in sorting out these possibilities. Traces of reuse and

exhaustion on these tools may include evidence for marginal flaking, which is likely to have had the greatest impact on width measurements, as their lateral margins represented the working edges of these tools. As tool width was reduced through resharpening of the lateral edges, changes in the ratio of edge thickness to overall thickness would have occurred, as the thickness at the margins of the tools began to approach the point of maximum tool thickness. No evidence exists to suggest that any of these tools were hafted, with the exception of the Humpback Scrapers, which exhibited straight, thick stems. Although lack of hafting might suggest little emphasis on curation in some tool classes, the great effort expended in the manufacture of some of these scrapers, especially those with near complete dorsal flaking, suggests that they were produced with the expectation of extended periods of use and maintenance. Investing greater effort in the manufacture of dorsally flaked specimens, with more refined outline morphologies, might imply anticipation of prolonged use life. In addition to these more formal implements, several minimally modified specimens were represented. It might be argued that these tools, which received lesser degrees of investment in production, were perhaps less apt to have been curated. Some of these minimally modified specimens were produced from blades. Investment in the manufacture of these tools was directed at core and blank production, rather than toward tool modification, so that blanks required little post-detachment alteration in order to transform flakes into usable implements. Among the Early Period End Scrapers, at least, width was highly standardized across all End Scraper modification types (complete dorsal, marginally flaked, and blade specimens), and proximal thickness was either highly standardized or moderately standardized. All other attributes were less consistent across the modification type categories. Consistency not only in degree of standardization but also in mean proximal thickness values suggests that consistency in this attribute was necessary to enable these tools to be hafted. It is

likely that the haft elements were curated, with stone bits being removed and replaced as they broke. Consistency in proximal thickness measurements across all End Scrapers would facilitate easy replacement in split hafts.

The frequent recovery of proximal fragments among the Unifaces likely reflects the greater ease with which many distal portions could be classified into types. Proximal portions of different categories of Unifaces often tend to look much the same, as they essentially represent unmodified or minimally modified proximal flake fragments. Distal ends, on the other hand, were more apt to have been modified to perform a particular function, thereby creating characteristic attributes that allow them to be classified into any one of a number of flake tool categories. The low levels of standardization among most of the general Unifaces may reflect either an absence of hafting modifications, or the introduction of variability through the reduction of numerous type categories into a single general and rather artificial category. Because of the fragmentary nature of most of these implements, and my resultant inability to classify them into particular type categories based on their techno-morphological characteristics and assumed function, it is difficult to speak to any decisions that toolmakers made regarding the point at which to discard these artifacts. These fragments could easily represent a) broken proximal fragments of specimens being returned in hafts for retooling, b) fragments of implements broken during manufacture, or c) fragments of implements broken during use at the site. The lack of standardization in proximal measurements might indicate a lack of emphasis on hafting modifications, thereby discounting the possibility that they represent hafted fragments of tools used off-site. But the potentially mixed nature of this “class” may mask the presence of hafted tool fragments intermingled with unhafted implements, or may represent a comingling of tools from different classes with varied haft element sizes.

The Gravers, most of which were complete or relatively complete, likely were used in tool manufacture or artistic applications, such as splitting or engraving bone, wood, or antler. The function of these implements will be discussed in greater detail in the following chapter. Both tool manufacture and artistic pursuits are activities that likely would have been carried out during periods of down-time, rather than at specialized sites where time stress on completion of other activities was a concern. The use of such implements on sites where more generalized residential activities were occurring is a more likely scenario. These activities could include gearing-up for future episodes of tool use away from the site. Gravers, therefore, are not likely to have been transported or curated. Instead, they could have been used in the creation of tool components such as hafts or foreshafts that would then have been used, either at the site or at other locales, to carry out tasks such as hunting or processing/butchering. It is likely, therefore, that the Gravers were being produced and used on-site, rather than being brought in from elsewhere, or returned for retooling. The complete/relatively complete nature of these specimens may be a function of the thickness of their bits compared to bit length. Graver spurs tended to be short and thick, perhaps making them a little less prone to breakage. In addition, these tools were produced from simple flakes and could, therefore, have been replaced rather easily once they became exhausted or neared the point of breakage.

While more fragmentary specimens were recorded among the Intentionally Modified Flakes than among the Unintentionally Modified specimens, it is important to remember that it can be difficult to distinguish between expedient flake tools that were broken during modification or use and those that were *produced* on flake fragments. If modification extended across the surface of the break then we could make this distinction but otherwise this is a difficult one to recognize. Regardless of the timing of these breaks, though, the minimally

modified nature of these specimens suggests nearly immediate periods of production, use, and discard of tools fashioned from various expediently-selected flakes and, possibly, flake fragments.

No particular patterning in fragmentation was noted among the tools produced from blades. It is possible that fragmentary examples of both Intentionally and Unintentionally Modified Blades were produced from blanks broken during manufacture that were then deemed unacceptable for modification into other tool types. While blades could have been produced for transport and transformation into tools while away from the production locale, specimens that were broken during manufacture likely would not have been selected for transport and, instead, might have been discarded at Dust Cave, offering the potential for expedient use while toolmakers were stationed at the site. Alternatively, these implements might represent blanks that were broken either during transport to or modification at other sites, or that survived the settlement cycle unscathed and were broken during modification or use upon their return to Dust Cave. It is less likely that fragmentary blanks would have been transported back to Dust Cave, as the area surrounding the site is replete with raw materials that could be utilized to produce expedient flake tools. For mobile hunter-gatherers, for whom “packing light” is a necessity, it would make little sense to spend energy transporting materials that could be obtained easily at the destination. The lack of evidence on these tools for repeated episodes of resharpening suggests that they were being used and discarded almost immediately. It is likely, therefore, that they are tools that were used on-site.

Tool Condition: Mid Levels (Early Side Notched and Kirk Stemmed Zones P, Q, and R)

Zone R: Early Side Notched

The Early Side Notched Zone revealed a total of 20 complete, 14 relatively complete, and 101 fragmentary tools, as well as 5 specimens of unknown condition (Table 7.85). A great majority of these tools are fragmentary (72%), representing a notable increase over the proportion of fragmentary tools in the Paleoindian levels. As with the Paleoindian specimens, not all tool classes follow this same pattern.

The majority of Stage Bifaces (ESB and MSB) and Trimmed Bifaces (I and II) are fragmentary. The Early Stage Biface fragments included 1 medial and 1 lateral portion, while the Mid Stage Biface fragments were both broken transversely. The Trimmed Biface I fragments included 14 distal fragments, 7 proximal fragments, 3 lateral fragments, and 2 medial fragments. Four (n=4) other less dramatically damaged Trimmed Biface I specimens were recovered, two (n=2) with damage to the distal end, one (n=1) with damage to a lateral margin, and one (n=1) with damage to the proximal end. The Trimmed Biface II fragments included 11 distal, 9 proximal, and 4 lateral portions. In addition, one (n=1) surface fragment and a basal corner (n=1) were recovered. Of the small number of bifacial Drills that were found, all were fragmentary and included 3 distal and 2 proximal fragments.

Among the Scrapers, patterns in tool condition are difficult to discern because of the small sample sizes, but most specimens are complete/relatively complete. Only one fragmentary specimen was recovered, a distal segment of a Humpback Scraper.

Table 7.85: Tool Condition, Early Side Notched. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
ESCR (n=2)	2	0	0	0
HSCR (n=1)	0	0	1	0
OSCR (n=1)	0	1	0	0
UNF (n=14)	3	1	10	0
DRL (n=5)	0	0	5	0
GRV (n=1)	0	0	1	0
ESB (n=2)	0	0	2	0
MSB (n=2)	0	0	2	0
TBI (n=36)	6	4	26	0
TBII (n=28)	0	0	28	0
RFL (n=24)	4	4	12	4
UFL (n=52)	4	3	11	0
BLD (n=2)	0	0	1	1
RBLD (n=2)	0	0	2	0
UBLD (n=1)	1	0	0	0
BSCR (n=1)	0	1	0	0

ESCR = End Scraper; HSCR = Humpback Scraper; OSCR = Ovoid Scraper; UNF = General Uniface; DRL = Drill; GRV = Graver; ESB = Early Stage Biface; MSB = Mid Stage Biface; RFL = Intentionally Modified Flake; UFL = Unintentionally Modified Flake; BLD = Unmodified Blade; RBLD = Intentionally Modified Blade; UBLD = Unintentionally Modified Blade; BSCR = Blade Scraper

The single Graver specimen from this zone was fragmentary, as were the majority of the general Unifaces (UNF) recovered. The fragmentary general Unifaces included 4 proximal and 4 distal pieces, as well as one medial, and one lateral fragment. The solitary Graver (GRV) fragment was a medial portion.

Among the expediently produced flake tools (UFL, RFL), more fragments were recovered, although the difference between the number of fragmentary and complete/relatively complete specimens was not large.

The representation of fragmentary and complete/relatively complete tools is quite comparable for all classes of blade tools. The single (n=1) fragmentary unmodified Blade is a distal fragment. Of the two (n=2) Intentionally Modified Blade fragments, one was a proximal fragment, and the other was a medial portion.

Zone Q: Mixed Early Side-Notched/Kirk Stemmed

The information gleaned from examination of these mixed deposits is not terribly informative because the mixed nature of the deposits does not allow any temporally-specific patterns to be identified, and the sample sizes are so small that any apparent “patterns” are suspect. The mixed Early Side-Notched/Kirk Stemmed Zone produced 7 complete, 2 relatively complete, and 25 fragmentary specimens, as well as 3 tools of unknown condition. Nearly 68% of the sample is fragmentary (Table 7.86).

The only pattern that is somewhat distinct is seen in the collection of Trimmed Biface II specimens, where we see a much greater frequency of fragmentary than complete items. Of these fragments, I recorded 5 distal and 4 proximal fragments, as well as a single medial fragment (n=1) and a surface fragment (n=1). More fragmentary Trimmed Biface I specimens were also recovered than complete/relatively complete ones, but the margin is not a wide one. The Trimmed Biface I fragments include 3 distal and 2 proximal portions. All other patterns are significantly less distinct.

Two Mid Stage Bifaces were recovered, including a single transversely broken specimen. The only Drill recovered was fragmentary, a distal segment.

Table 7.86: Tool Condition, Mixed Early Side Notched/Kirk Stemmed. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
General Uniface (UNF)	1	0	0	0
Drill (DRL)	0	0	1	0
Mid Stage Biface (MSB)	0	1	1	0
Trimmed Biface I (TBI)	1	1	5	0
Trimmed Biface II (TBII)	2	0	12	0
Intentionally Modified Flake (RFL)	0	0	0	3
Unintentionally Modified Flake (UFL)	3	0	6	0

Zone P: Kirk Stemmed

The Kirk Stemmed zone produced a total of 19 complete, 9 relatively complete, and 69 fragmentary specimens, as well as 2 of unknown condition (Table 7.87). The fragmentary specimens make up 70% of the Kirk Stemmed assemblage. This is the second highest proportion of fragmentary specimens noted for any time period, next to the Benton Zone D assemblage.

Most of the Stage Bifaces were fragmentary, with only a small handful of complete or relatively complete specimens recovered. Two Mid Stage Biface fragments were broken transversely. The majority of Trimmed Biface I specimens were fragmentary, with most fragments being distal (n=8) or proximal portions (n=8). In addition, I recorded 5 medial fragments. The Trimmed Biface II fragments included 11 distal, 8 medial, 4 proximal, and 1 longitudinal. More fragmentary than complete/relatively complete Drills were recorded, although the difference in counts is very small (n=2). The Drill fragments included 2 proximal and 2 medial fragments.

The number of unifacial tools recovered from this zone was very small. Of the seven Scrapers discovered, all were complete or relatively complete. Similarly, the single general

Uniface that was recorded was complete. The only fragmentary unifacial specimen was the single distal Perforator fragment.

Table 7.87: Tool Condition, Kirk Stemmed. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
End Scraper (ESCR)	4	2	0	0
Humpback Scraper (HSCR)	1	0	0	0
General Uniface (UNF)	1	0	0	0
Drill (DRL)	0	2	4	0
Perforator (PERF)	0	0	1	0
Mid Stage Biface (MSB)	0	0	3	0
Trimmed Biface I (TBI)	3	1	21	1
Trimmed Biface II (TBII)	2	0	24	0
Intentionally Modified Flake (RFL)	0	1	1	1
Unintentionally Modified Flake (UFL)	7	2	11	0
Unmodified Blade (BLD)	1	0	4	0
Blade Scraper (BSCR)	0	1	0	0

Among the expediently produced flake implements we see fairly even representation of fragmentary and complete/relatively complete specimens. This pattern is noted for both the Intentionally (RFL) and Unintentionally Modified Flake (UFL) specimens, although the number of Intentionally Modified Flakes recovered was low (n=2).

The unmodified blades from the Kirk Stemmed zone are mostly fragmentary, and the single blade scraper is relatively complete. Among the Unmodified Blades, I recorded one distal, one medial, and 2 proximal fragments.

General Mid Levels

The collection of tools recovered from the general Mid Levels includes 33 complete, 19 relatively complete, and 118 fragmentary specimens, as well as 4 tools of unknown condition.

The majority of these specimens (68%) are fragmentary (Table 7.88).

Table 7.88: Tool Condition, General Mid Levels. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
Mid Stage Biface (MSB)	0	0	3	0
Trimmed Biface I (TBI)	5	0	29	3
Trimmed Biface II (TBII)	6	4	38	0
General Uniface (UNF)	0	1	7	0
Drill (DRL)	0	2	4	0
Graver (GRV)	0	0	1	0
End Scraper (ESCR)	1	0	0	0
Ovoid Scraper (OSCR)	1	0	0	0
Intentionally Modified Flake (RFL)	5	4	16	0
Unintentionally Modified Flake (UFL)	13	8	19	0
Unmodified Blade (BLD)	0	0	0	1
Intentionally Modified Blade (RBLD)	1	0	1	0
Blade Scraper (BSCR)	1	0	0	0

As with the specimens from the specific zones in the Mid levels, the Stage Bifaces (MSB, TBI, and TBII) from the general zones are primarily fragmentary. Among the MSB fragments, 2 were broken transversely. The Trimmed Biface I fragments included 10 distal, 9 proximal, 7 medial, and 2 lateral pieces. The majority of Trimmed Biface II fragments were distal pieces (n=19), although I also recorded 9 lateral, 5 proximal, and 2 medial fragments. Few Drills were assigned to the general Mid Levels, but most specimens were fragmentary, mirroring the pattern

noted in the specific Early Side Notched and Kirk Stemmed zones. The Drill fragments included 2 distal and 2 medial portions.

The majority of general Unifaces recovered were fragmentary, as was the single Graver specimen. The Unifaces included 3 lateral and 2 medial fragments, as well as a proximal portion. The fragmentary Graver specimen was a bit fragment. Only two Scrapers were assigned to the general Mid Levels, and both were complete. These observations seem to correspond to the patterns noted from the specific zones.

Most of the Intentionally Modified Flakes from these general levels were fragmentary, although several complete and relatively complete specimens were also recovered. Among the Unintentionally Modified Flakes, the numbers of fragmentary and complete/relatively complete specimens are fairly even.

Few blade tools were assigned to the general levels. Two Intentionally Modified Blades were recovered, one complete and one a proximal fragment. The single Blade Scraper recovered was a complete specimen. So few blade tools were recovered from any of the Early Side Notched and Kirk Stemmed zones that it was impossible to discern any patterning in discard condition.

Discussion: Mid Levels

Bifaces, in all of the Mid level periods, were more often fragmentary than complete or relatively complete. Early Stage Bifaces were recovered only from the Early Side Notched zone and were represented by only two (n=2) fragmentary specimens, making any assessment of patterning impossible. The breaks included a medial and a lateral fragment. As these fragments exhibited no evidence for use, they likely represent specimens damaged during manufacture on

the site, as they were produced from locally available material. All Mid Stage Bifaces exhibited transverse breaks that, along with the lack of evidence for use on these specimens, suggest damage during production. Trimmed Bifaces were most often fragmentary. Among the Early Side Notched Trimmed Biface I specimens, most fragments were proximal portions, while proximal and distal fragments were noted with equivalent frequency in the Kirk Stemmed sample. Distal portions were most common among the Trimmed Biface II fragments. With no real evidence for use noted on any of these specimens, it is likely that the various Bifaces were broken during manufacture.

All bifacial Drills recovered were fragmentary; these included proximal, medial, and distal segments. The presence of medial and distal fragments suggests that these items were used, broken, and discarded on-site, as it is unlikely that these broken pieces would have been transported back to Dust Cave for discard. Proximal fragments could have been returned to the site still attached to the haft, and discarded as part of retooling activities, but the presence of distal and medial fragments is suggestive instead of use at the site, likely in tool manufacture. Without refits, though, it is difficult to determine whether the proximal fragments represent tools used at the site, or broken haft portions returned to the site for retooling. At least some drills, though, are likely to have been used at Dust Cave, given that tool production seems to have been occurring on-site.

Few Scrapers were recovered from the Mid levels, so little interpretation of patterning is possible. Most specimens were complete or relatively complete. It is possible that these artifacts represent implements that were utilized and discarded on-site, or ones that were returned, exhausted, to the site as part of a retooling strategy. This question will be considered in greater detail in the following section, in which I discuss patterns of use and discard.

Few other unifacial tool types were recovered from the Mid period zones. Most were fragmentary, including the small number of Gravers that were recovered. Condition of many of the other Uniface specimens was hard to assess because the categories (“single edged,” “multi edged”) may, in reality, encompass a variety of tool types that became fragmented and were otherwise unidentifiable.

Among the minimally flaked tools (UFL, RFL), more fragments were noted than complete or relatively complete specimens. It is difficult to discern, however, whether these represent flake fragments that were repurposed into expedient tools, or expedient tools that were broken during use.

No particular patterning in tool condition was noted among any of the blade tools. Whole and fragmentary specimens were noted in nearly equivalent proportions.

Tool Condition: Late A Levels (Eva/Morrow Mountain Zones E, J, K, N)

Zones E, J, K, N: Eva/Morrow Mountain

In the several Eva/Morrow Mountain zones defined at the site, excavations revealed 29 complete, 13 relatively complete, and 84 fragmentary specimens, as well as 3 tools of unknown condition. The majority of specimens (65%) are fragmentary (Table 7.89).

Among the earlier stage bifaces (ESB, MSB) we see fairly even numbers of complete/relatively complete and fragmentary specimens. Nearly all of the fragmentary Early Stage Biface and Mid Stage Biface fragments were portions of tools that were broken transversely (n=2 in each category), but one Mid Stage Biface specimen with a hinge fracture was also recorded. Trimmed Bifaces (TBI and TBII) were more commonly recovered as fragmentary specimens. The Trimmed Biface I fragments included 9 proximal, 5 medial, and 4

distal portions, as well as one that was simply identified as having been broken transversely.

Among the Trimmed Biface II fragments, most were distal portions (n=24). In addition, proximal (n=10), medial (n=9), and lateral (n=1) fragments were recorded. All of the Drills recovered were fragmentary, including 1 medial, 1 proximal, and 2 distal portions.

Few unifacial tools were attributed to the Eva/Morrow Mountain zones. A small sample of End Scrapers was recovered, and most of these specimens were complete or relatively complete. The one fragmentary specimen was a distal portion. Similarly, the single Side Scraper was relatively complete. Of the two general Unifaces, one was relatively complete while the other was fragmentary (proximal). Two Perforators were recovered. One of these specimens was relatively complete and the other was fragmentary (distal).

Table 7.89: Tool Condition, Eva/Morrow Mountain. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
End Scraper (ESCR)	1	1	1	0
Side Scraper (SSCR)	0	1	0	0
General Uniface (UNF)	0	1	1	0
Drill (DRL)	0	0	4	0
Perforator (PERF)	0	1	1	0
Early Stage Biface (ESB)	2	0	2	0
Mid Stage Biface (MSB)	3	2	3	0
Trimmed Biface I (TBI)	5	2	19	1
Trimmed Biface II (TBII)	9	2	44	0
Intentionally Modified Flake (RFL)	1	1	1	1
Unintentionally Modified Blade (UFL)	6	2	7	0
Unmodified Blade (BLD)	1	0	1	1
Unintentionally Modified Blade (UBLD)	1	0	0	0

In the categories of Intentionally and Unintentionally Modified Flakes, complete and fragmentary specimens were recovered in nearly equal proportions, with complete/relatively complete finds slightly outnumbering the fragmentary specimens in both categories.

Only one Intentionally Modified Blade was recovered from these zones, and this specimen was intact.

General Late A Levels

The general Late A levels, which correspond to the same depths as the Eva/Morrow Mountain deposits, produced a total of 45 complete, 23 relatively complete, and 144 fragmentary specimens (Table 7.90). The majority of tools from these levels are fragmentary (68%).

Among the bifaces, fragmentary specimens tend to outnumber complete/relatively complete examples. Only three Mid Stage Bifaces were recovered. Two of these were fragmentary, while only one was complete. Of the two fragments, one was unknown and one was a lateral portion. The later stage Trimmed Biface I and II categories included far more fragmentary than complete/relatively complete specimens. Fragmentary Trimmed Biface I specimens include 17 proximal, 11 distal, 11 medial, and 2 lateral pieces, while the fragmentary TBII specimens included 21 distal, 14 proximal, 14 medial, and 6 lateral pieces. Fragmentary drills also outnumbered complete specimens. Among the Drill fragments were 4 medial and 2 distal portions.

Among the Unifaces, fairly even numbers of complete/relatively complete and fragmentary specimens were recovered. Given the small number of unifacial tools identified from these general levels, it is likely that any apparent patterns in their condition are statistically meaningless. Only one End Scraper was identified; this specimen was complete. All of the

general Unifaces that were recovered were fragmentary (2 proximal, 1 lateral), while the single Perforator was relatively complete.

Table 7.90: Tool Condition, General Late A Levels. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
Mid Stage Biface (MSB)	1	0	2	0
Trimmed Biface I (TBI)	6	5	42	0
Trimmed Biface II (TBII)	2	1	55	0
General Uniface (UNF)	0	0	3	0
Drill (DRL)	2	0	6	0
Perforator (PERF)	0	1	0	0
End Scraper (ESCR)	1	0	0	0
Intentionally Modified Flake (RFL)	2	3	7	0
Unintentionally Modified Flake (UFL)	29	11	27	0
Blade (BLD)	0	0	2	0
Unintentionally Modified Blade (UBLD)	2	2	0	0

Examination of the expediently produced flake tools revealed more complete/relatively complete specimens among the Unintentionally Modified Flakes (UFL) and fairly even representation of complete/relatively complete and fragmentary specimens among the Intentionally Modified Flakes (RFL).

Very few blade tools were identified, and all of the Unintentionally Modified Blades were complete or relatively complete.

Tool Condition: Late B Levels (Benton Zone D)

Zone D: Benton

The Benton zone produced a total of 8 complete, 7 relatively complete, and 48 fragmentary specimens, as well as 3 tools of unknown condition (Table 7.91). The proportion of fragmentary tools seen in this zone is the highest from any time period at the site (73%).

With the exception of the Early Stage Bifaces, most of the bifacial specimens recovered were fragmentary. Among the fragmentary Mid Stage Bifaces, one was a medial portion, while the remaining three were recorded as having been broken transversely. Fragmentary artifacts dramatically outnumbered complete/relatively complete specimens in the categories of Trimmed Biface I and II. Among the fragmentary Trimmed Biface I specimens, 5 were proximal, 4 were medial, and 2 were distal pieces. The Trimmed Biface II fragments included 11 distal, 9 medial, 6 proximal pieces, and a single lateral fragment.

Table 7.91: Tool Condition, Benton. (Data available in Appendix A.)

Tool Class	Condition			
	Complete	Relatively Complete	Fragmentary	Unknown
Early Stage Biface (ESB)	5	1	0	0
Mid Stage Biface (MSB)	0	1	4	0
Trimmed Biface I (TBI)	1	1	11	0
Trimmed Biface II (TBII)	1	1	27	0
Intentionally Modified Flake (RFL)	0	1	0	1
Unintentionally Modified Flake (UFL)	1	2	6	0
Unmodified Blade (BLD)	0	0	0	2

Only one Intentionally Modified Flake was recovered, and it was a relatively complete specimen. In contrast, the Unintentionally Modified Flakes were more frequently fragmentary, although neither the sample size nor the margin of difference was large.

General Late B Levels

The general Late B levels, which are associated with the depths of the Seven Mile Island phase deposits, produced a total of 39 complete, 18 relatively complete, and 111 fragmentary specimens, as well as 2 tools of unknown condition (Table 7.92). The majority of tools from these general levels are fragmentary (65%).

Among the bifaces from these levels, more fragmentary specimens were recovered than complete/relatively complete examples. All Early Stage Bifaces were complete/relatively complete, but among the Mid Stage Bifaces and the Trimmed Biface I and II categories, more fragmentary specimens were recorded. The Mid Stage Biface fragments include two lateral fragments, one piece that was broken transversely, and one specimen that exhibited a hinge fracture. Among the Trimmed Biface I fragments, 10 were proximal pieces, 8 were medial fragments, and 1 was a longitudinal portion. The Trimmed Biface II fragment included 15 distal, 14 medial, 13 proximal, and 4 lateral pieces. The single drill attributed to these general levels was a proximal fragment.

Of the general Unifaces that were recovered, the numbers of complete/relatively complete and fragmentary specimens were nearly equivalent. The fragmentary specimens included a lateral, a distal, and a medial portion.

Among the expediently produced flake tools (RFL, UFL), more complete/relatively complete specimens were recovered than fragmentary examples.

Table 7.92: Tool Condition, General Late B levels. (Data available in Appendix A.)

	Condition			
Tool Class	Complete	Relatively Complete	Fragmentary	Unknown
Early Stage Biface (ESB)	2	1	0	0
Mid Stage Biface (MSB)	1	1	5	1
Trimmed Biface I (TBI)	1	3	25	0
Trimmed Biface II (TBII)	2	1	48	0
General Uniface (UNF)	1	1	3	0
Drill (DRL)	0	0	1	0
Intentionally Modified Flake (RFL)	8	3	4	1
Unintentionally Modified Flake (UFL)	24	8	25	0

Discussion: Late Levels

In both the Late A and Late B period samples, the earlier Stage Bifaces (ESB, MSB) often were represented fairly evenly by complete/relatively complete and fragmentary examples. Those Early Stage Bifaces and Mid Stage Bifaces that were fragmentary tended to exhibit transverse breaks, which, in association with a lack of wear traces, suggests that they were broken during manufacture. The Trimmed Bifaces were more often fragmentary than complete or relatively complete. Trimmed Biface I fragments were most often represented by proximal or medial portions, while Trimmed Biface II specimens were more often recovered as distal or medial fragments. As discussed above, this apparent pattern may relate to the greater amounts of modification required to create the refined, pointed distal ends of these tools, compared to the lesser amounts necessary to modify the proximal segments.

A small number of bifacial Drills were recovered from the Late levels. All of these specimens were fragmentary and included various portions of the tools. The presence of distal

and medial segments provides good evidence for use and breakage of these tools on-site, as these fragments are less likely to have been returned to the site for retooling.

The few unifacial tools that were recovered from these levels included a small number of mostly complete End Scrapers. The following section considers degrees of exhaustion of these tools, which should provide some insight into whether the scrapers were being used on-site, or whether they represent items that were curated and return to the site for retooling and discard. One relatively complete Side Scraper was also recovered. The Side Scrapers, which appear to have been used as cutting implements rather than as scraping tools, may very well have been used on-site. Two Perforators were recovered, one complete and one fragmentary. The distal fragment suggests that these tools may have been used on-site. It is difficult to make any assessment of the General Unifaces, as the sub-categories may have represented collections of varied fragmentary tool types. The General Unifaces were represented by relatively even numbers of complete/relatively complete and fragmentary specimens.

The Intentionally and Unintentionally Modified Flake tools recovered from the site were likely used on-site, and included implements in a variety of conditions.

TOOL CONDITION: USE LIFE AND REMAINING UTILITY

We see, from the previous discussion, that tools were recovered in various states of completeness after being discarded, abandoned, or lost at Dust Cave. Some of these implements may have been discarded during production, either upon breaking during manufacture or upon recognition of a flaw. Others may have been discarded during the course of use at the site, either having broken during use, or having been discarded intact after use. Certain others may have been discarded at the site after having been used off-site to the point of exhaustion, when

maximum utility had been extracted. Such tools may have been curated and returned to the site for retooling, and for reuse of the harder-to-produce hafts. Each of these possibilities should leave distinct traces in the archaeological record and may inform on the nature of site use and on the factors that influenced tool design, beyond simply the functional requirements of the piece. Examination of these patterns can demonstrate whether tools were being produced for immediate use, or whether they were produced in anticipation of prolonged future use. They can provide insight into the types of adaptive challenges that were being met through the production of implements that were designed for extended use and multiple resharpening episodes or for immediate use and discard. And they provide insight into toolmakers' decisions regarding when to discard an implement, specifically whether it is beneficial to discard a tool before the potential for tool failure (i.e., while potential utility still remains), or to wait until its maximum utility has been realized.

If tools were discarded in response to breakage during manufacture, we would expect to see fragmentary specimens that retained no traces of use. These unused fragmentary specimens might or might not exhibit characteristics of the completed tool form. In other words, they may have been broken prior to receiving the "finishing touches," such as final refinement of the working edge, or application of hafting modifications. These tools would exhibit no evidence for use or resharpening, such as reduction of length or width, changes in edge morphology, removal of flakes for resharpening, microchipping or rounding of the edge, etc. Particular break types might also be expected among such a collection of tools. These characteristic fracture types have been discussed, above (Ch. 5).

On the other hand, tools that were discarded during or after use on-site would retain evidence for use, including changes in their dimensions, morphology, working edge angles, etc.

These specimens could have entered the archaeological record whole or broken. Some may have been simple tools without hafting modifications that were produced and used expediently. Others may have been more complex, hafted implements that were also curated and transported off-site for use elsewhere. Barring reuse of fragments through recycling into other tool forms, fragmentary specimens would be expected to include fairly even representation of proximal and distal portions.

If tools were being used off-site and returned to Dust Cave for retooling, particular breakage patterns might be predicted in the sample, along with evidence for high degrees of utility having been extracted. If tools were produced for use off-site, toolmakers likely would have anticipated extended periods of use away from the easily accessible raw material source in the vicinity of Dust Cave. Under such conditions we might expect that tools were produced with hafting elements and characteristics that would have facilitated resharpening or recycling (e.g., use of high-quality raw materials, production of larger implements, production of thicker implements that would be resistant to breakage during transport, etc.). Because the hafts would have been more time-consuming to produce than the stone tool bits, it is likely that broken or exhausted hafted tools would have been returned to the site and discarded so that hafts could have been reused. In such a case, we should see a greater abundance of proximal fragments, and few distal fragments, as distal portions likely would have been abandoned at the location of use, rather than being transported to a retooling locale. Whole tools might be expected to exhibit changes in dimensions through progressive resharpening episodes, including reduced length or width, depending on the location of wear and resharpening. Tool morphology might be expected to change among some tool classes, as alterations to the working edge often occur as a result of wear and resharpening. These changes include changes in the working edge angle or edge

morphology, such as the production of beveling, incurvature, recurvature, or flattening of convex portions.

In the following section, use life stages and remaining utility are discussed for the various tool classes represented at Dust Cave. This discussion encompasses a review of the degrees of tool use represented, as well as the results of use-life/utility analysis.

Bifaces

The category of Bifaces includes Stage Bifaces (Early and Mid), Trimmed Bifaces (TBI and TBII), Hafted Bifaces, Probable Hafted Bifaces, and Bifacial Drills. I did not examine the Stage or Trimmed Bifaces from the perspective of changes associated with extraction of use-life because examination of these implements during the early phases of my selection procedure for use-wear examination revealed no evidence that these implements experienced use. Edges exhibited no evidence for crushing, microchipping, rounding, or resharpening, and fracture patterns within these categories suggested that breakage occurred during manufacture, rather than during use. It is unlikely, therefore, that any evidence for use in the form of changes in dimensions or morphology, nor any evidence for extraction of utility from these implements would have been noted. It appears that these bifaces, from earlier in the reduction sequence, were being manufactured on-site and were discarded if they were broken or deemed to be flawed during the manufacturing process.

Hafted and Probable Hafted Bifaces were not considered in any detail in this study, in large part because this class of tools has received substantial attention over decades of archaeological research. This long history of research has revealed that such implements, which often serve as valuable temporal-cultural markers, were hafted tools that served as projectile tips

and/or knives. They tended to be cared for, transported, resharpened, and even reused or recycled, thus representing an excellent example of a class of “curated” tools. The amount of effort expended in the production of these tools and their hafts suggests anticipation of long-term or intensive use by both the makers and users of these implements. The expectation of long or intense use-lives may explain the reliance on high-quality raw materials with great potential for resharpening. Randall (2001) noted an exception to this suggestion, as many of the Early Side Notched Hafted Bifaces were discarded prior to undergoing much resharpening. This pattern may be, in part, a function of the proximity of the Dust Cave population to a source of Blue-Grey Fort Payne chert.

These tools were attached to hafts, which are more time consuming to produce. As such, we might expect to see proximal fragments on-site, representing broken specimens that were simply returned to the site, in the haft, for retooling. In this case, distal fragments, with evidence for use (e.g., resharpening, microchipping, impact fractures) would be absent, as these are more likely to have been abandoned at the location of use, away from Dust Cave. Alternatively, fragmentary specimens could represent tools that were broken during manufacture on-site. In this case, though, we would expect to see both proximal and distal fragments represented, with no evidence for use on any of these segments. In addition, we might expect to see recycled Hafted Bifaces being returned to the site in their hafts. Among certain tool classes (e.g., Drills), we see hafting modifications similar to those noted on complete/relatively complete Hafted Bifaces. While it is difficult to say for certain whether or not these represent recycled, damaged projectile tips, we cannot discount the possibility.

Drills

It is difficult to say much about the bifacial Drills, as so few specimens that could be associated with a specific or general zone were recovered in either complete or relatively complete condition. Most Drills were recovered as proximal fragments, making assessment of reduction difficult, as most of the use- and resharpening-related changes we might expect to see would have impacted characteristics of the distal (bit) portion. The bit may have had length removed both through use-related attrition, and through resharpening, while bit thickness might have experienced less reduction. Proximal (haft) portions, on the other hand, likely would have remained essentially unaltered through use, with the exception of crushing or abrasion damage incurred through movement in the haft.

It might be possible, in theory, to examine length-to-width ratios for the distal fragments, in order to evaluate length reduction through use and resharpening. Without refits, though, it is impossible to determine whether the length of the bit fragment represents the *entire* bit length, or if it represents only a snapped portion of the bit.

Bit width-to-thickness ratios might instead be considered in order to assess changes resulting from use or resharpening. The bit ends of these Drills were generally diamond-shaped or biconvex in cross-section. By means of use-related attrition, or by means of edge maintenance or resharpening, the width of the tool bit may have become reduced more than the thickness of the tool. Changes in the width-to-thickness ratio may, therefore, represent progression through the use sequence. Presumably, once the bit portions became too narrow, they would have been prone to breakage, given the sorts of twisting forces applied during use of the drills. These tools might also have progressed to the point at which dimensions of the bit were no longer

appropriate to the task at hand (e.g., no longer making a deep enough hole in the drilled material). At this point, it is likely that tools would have been discarded.

While width is more likely to have changed through use and resharpening, thickness may also have become reduced, although to a lesser degree, through forces of attrition that removed material from the dorsal and ventral bit surfaces as they rubbed against the worked material. Any reduction in thickness likely would have occurred at a slower rate than reduction along the thinner, more fragile lateral bit margins.

Width-to-thickness ratios are considered for fragmentary specimens, particularly the distal and medial fragments, as width and thickness were not measured at the same point on the complete/relatively complete specimens as they were on the fragmentary pieces, and these measurements on the proximal drill fragments (hafts) were not representative of the bit dimensions. The sample sizes were generally small but showed that most of the fragmentary specimens exhibited width-to-thickness ratios between about 1.6:1 and 1.8:1 in the three main periods (Early, Mid, Late) (Tables 7.93, 7.94, 7.95). No significant differences were noted in the mean ratios between periods (asymptotic significance: 0.581; see Table 7.96), leading me to consider three possible explanations for the similarities: a) tools were manufactured to these specifications and these represent items that were broken during or around the time of manufacture, before they became reduced; b) they were resharpened only to a specific point, beyond which they were deemed unusable; or c) they broke at critical width-to-thickness measurements, perhaps once they became too narrow to withstand the forces applied during use. It is difficult to assess the validity of any of these possibilities without being able to compare these results to length measurements, which might also have changed over the course of resharpening. For any useful analysis of the drill sample to be performed, a greater number of

complete/relatively complete specimens would be required in order to allow an assessment of changes in bit length, bit width, and bit thickness in concert with one another.

Table 7.93: Drill Width to Thickness Ratios, Early Period. (Primary measurement data available in Appendix A, Table A-2.)

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
WIDTHHK	5	.70	1.45	2.15	1.7520	.26640
Valid N (listwise)	5					

Table 7.94: Drill Width to Thickness Ratios, Mid Period. (Primary measurement data available in Appendix A, Table A-2.)

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
WIDTHHK	7	.69	1.49	2.18	1.8329	.27103
Valid N (listwise)	7					

Table 7.95: Drill Width to Thickness Ratios, Late Period. (Primary measurement data available in Appendix A, Table A-2.)

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
WIDTHHK	2	.53	1.35	1.88	1.6150	.37477
Valid N (listwise)	2					

Table 7.96: Kruskal-Wallis Test for Significance of Differences in Drill Bit W:T Ratios.
(Primary measurement data available in Appendix A, Table A-2.)

Ranks

	ZONE	N	Mean Rank
WIDTHK	1	5	7.20
	2	7	8.43
	3	2	5.00
	Total	14	

Test Statistics^{a,b}

	WIDTHK
Chi-Square	1.087
df	2
Asymp. Sig.	.581

a. Kruskal Wallis Test

b. Grouping Variable: ZONE

Unifaces

The category of unifaces includes both more formal and less formal types, with differences in formality linked to different degrees of investment in modification, which may correspond to differences in degrees of curation and in anticipated periods of future use. The Uniface category includes classes of artifacts that likely were curated, and classes that may have been produced with more immediate use in mind. These differences in the ways that tools were conceived of and produced accounts for much of the variability in use and discard patterns noted across the various tool classes.

Scrapers

End Scrapers

The majority of End Scrapers were recovered from the Early period levels. This class of artifacts comprises two subclasses: one that exhibits only marginal flaking, and another that received complete dorsal flaking. A third category of Blade End Scrapers, discussed below, may be viewed as a subset of the marginally flaked category. While the marginally flaked category received less investment in post-detachment blank modification, analysis of attribute standardization, presented above, indicates that these implements were produced to conform to a particular template. Their proximal ends appear to have been modified to enable easy replacement of the stone bits in standardized and probably curated hafts. While the margins of these minimally flaked specimens required less intensive modification to be considered usable, the haft ends still received significant attention during production. As such, the differences noted in post-detachment modification are not necessarily an indicator of their position in the curated-expedient tool spectrum. Rather, all of these relatively formal tools (i.e., purposefully modified) likely were produced in anticipation of use over repeated or prolonged periods. To understand for how long and how intensively they were used, and when tool users made the decision to discard them, it is necessary to consider changes in particular attributes that become altered through use and rejuvenation of these implements.

The End Scraper specimens can be divided into those produced from blades, and those produced from a variety of non-blade blanks. The general “non-blade” catch-all category includes a variety of blank types that were discussed earlier in this chapter. The other category comprises those tools that were produced from specialized blades. These categories are discussed separately, and consideration is given to how they related to one another. Almost all of the Blade

End Scrapers were recovered from the Early Period zones. Only one specimen was recovered from the Mid Period zones.

By considering their morphology and the manner in which these tools are likely to have been used, based on observations from ethnographic accounts and microwear studies of similar artifacts, we may identify the sorts of changes that can be expected in dimensions and morphological characteristics through progressive episodes of use and resharpening. End Scrapers are elongated implements, which are often hafted, and which possess a relatively steep bit or working edge located at the distal end of the tool. Through numerous microwear studies, these tools have been interpreted as having been used in defleshing and removing the hair from animal skins.

As the working edge is pulled across the surface of the skin, it becomes dulled and requires resharpening in order to function effectively. While some researchers (e.g., Wilmsen 1970) have suggested that maintenance of an appropriate edge angle is crucial to End Scraper function, more recently Comstock (2011) and Seeman et al. (2013) have suggested that maintenance of a *sharp* scraping edge is of greater importance. Scraping may also be facilitated by the production and maintenance of a slightly convex bit, which prevents angular corners from digging into the hide. In order to provide additional leverage during use, these implements were often hafted, requiring certain modifications of the proximal end. Standardization in proximal measurements among the Early period End Scrapers has been discussed, and this pattern is considered suggestive of hafting modifications. The haft end of the implement changes little through use and resharpening, with the exception of exhibiting particular wear traces (e.g., crushing of edge margins, rounding/polishing of dorsal flake scars) that are the result of movement of the tool in the haft.

The most dramatic changes we see in End Scraper morphology through use and resharpening are those that affect the bit end. Lateral margins remain relatively untouched, with the exception of being reduced in length through the resharpening process (Shott 1995: 61-63). In addition to overall length reduction, two important sets of changes begin to occur as resharpening flakes are removed repeatedly from the distal end: alteration of the edge angle, and reduction in bit convexity (Andrefsky 1998: 35; Ellis and Deller 2000: 106-107; Morrow 1997: 77-78). Resharpening is accomplished by removing flakes from the bit end of the tool in order to sharpen the margin between the bit and the ventral surface. Pressure is applied to the ventral surface of the tool blank, and flakes are removed from the dorsal surface. It is this margin that is responsible for removing the grain, hair, and remaining flesh from the hides. Over the course of successive resharpening episodes, the bit begins to encroach on the tool-haft juncture. When this occurs, it becomes more difficult to remove flakes in quite the same manner as earlier resharpening episodes.

To understand the sorts of changes that occur in bit angle, it is necessary to consider the nature of flake morphology. Flakes tend to be thicker at their proximal ends, where the initial force applied radiates throughout the stone raw material creating the characteristic bulge known as the bulb of percussion. This bulb intrudes more deeply into the surface of the bit where it contacts the ventral surface than it does at the juncture between the bit and the dorsal surface, where the resharpening flake thins out. This means that a greater amount of material is removed from the cutting edge of the bit than from the edge that meets the dorsal surface of the tool, which may result in an increase in bit steepness. Once the bit begins to encroach on the haft, though, bit angle becomes progressively steeper and the depth of the resharpening flakes becomes restricted. At this time there is less room on the ventral surface for the bulb to expand

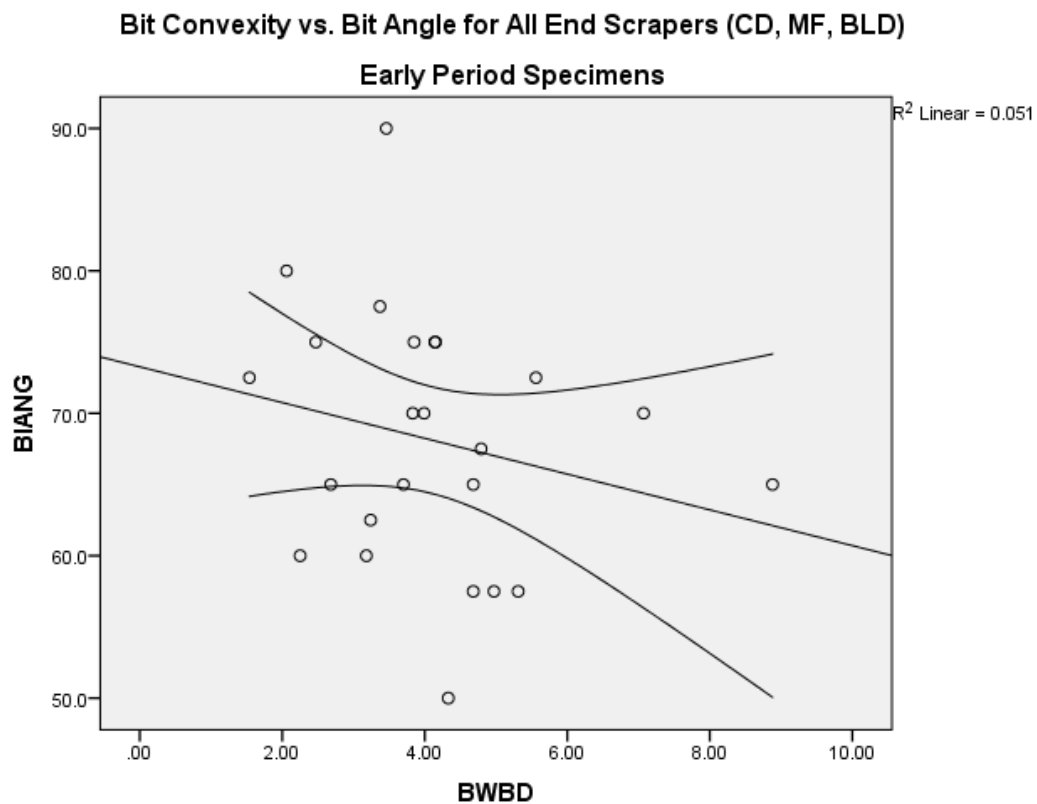
and less space available on the dorsal surface for the force to travel and remove a flake (i.e., flakes become shorter and steeper). The angle of flake removal therefore begins to change, creating a steeper edge angle as resharpening continues. These changes are likely to occur, regardless of the desired degree of edge sharpness.

At the same time that bit angle begins to change, we should also witness changes in the degree of bit convexity as the bit approaches the juncture with the haft. At the bit corners, where the bit meets the lateral tool margins, are where we see the “low” points of bit convexity, with the maximum point being near the midpoint of the bit margin. As resharpening progresses and tool length is reduced, the bit corners begin to encroach on the haft first. When this occurs, it becomes difficult for the tool user to resharpen the bit at the corners near the edge margins. Instead, resharpening efforts must be focused on higher points of bit convexity. As more and more of the “high point” of the bit is removed, the bit becomes progressively straighter (i.e., less convex). A tool that has undergone more episodes of use and resharpening should, therefore, exhibit both a steeper bit angle and a lower degree of bit convexity, measured as a change in the ratio of bit width to bit depth. Bit width should become greater in relation to bit depth as convexity is reduced.

In summary, as End Scrapers are used, dulled, and resharpened, tools should become shorter overall, while bits become steeper and flatter.

Early Period End Scrapers

Given the expected changes in the working edges of End Scrapers, as discussed above, I begin by considering the relationship between bit convexity and bit angle in the Early period specimens (Figure 7.1).



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.009	1	3.009	1.185	.288 ^b
	Residual	55.864	22	2.539		
	Total	58.873	23			

a. Dependent Variable: BWBD

b. Predictors: (Constant), BIAN

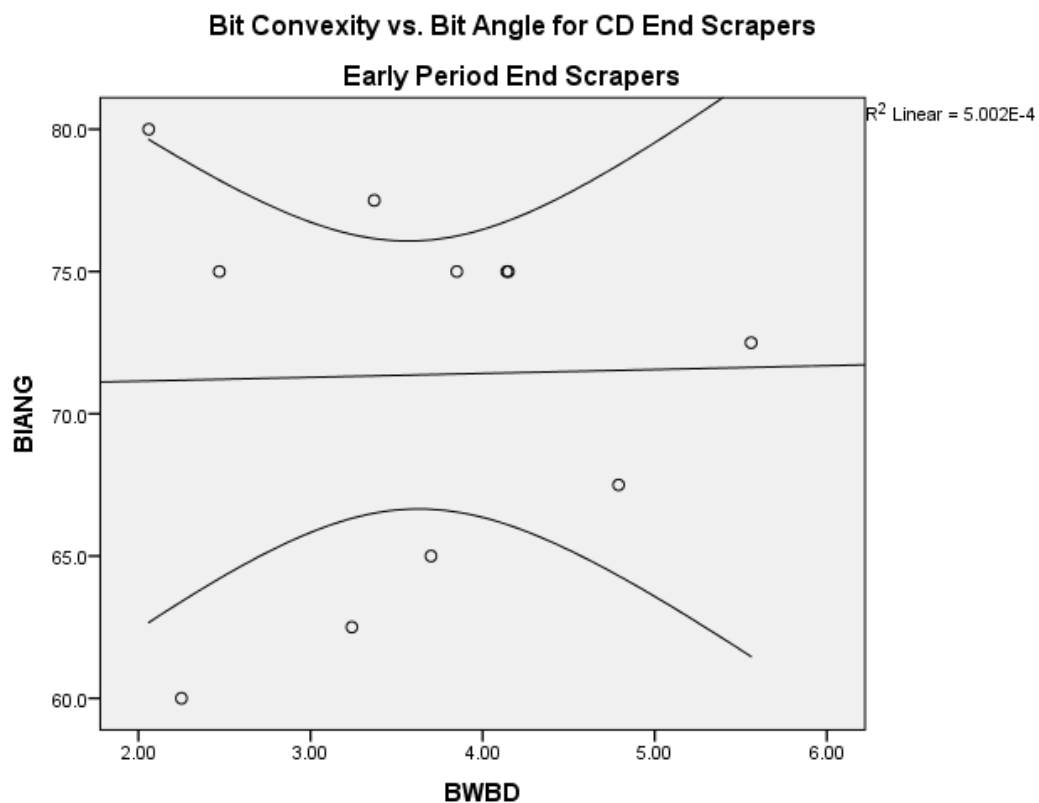
Figure 7.1: Scatterplot of Early Period End Scraper Bit Convexity vs. Bit Angles. (95% Confidence Interval shown. Primary measurement data available in Appendix A, Table A-3.)

Examination of the sample as a whole (i.e., not broken down by degree of dorsal modification, and also considering those specimens produced from blades) shows a weakly negative correlation between bit angle and bit convexity ($R^2 = 0.051$; $p = 0.288$). In other words, specimens with flatter bits tend to exhibit slightly more acute edge angles. This pattern runs contrary to the expectation that, as resharpening occurs, bits should become flatter (less convex) and steeper (higher bit angle). This correlation is not significant, though, and exhibit many outliers, suggesting that there may not be any connection between changes in these variables.

Among the dorsally flaked specimens, we see a very weakly positive slope, with no significant correlation between the variables ($R^2 = 5.002E^{-4}$, $p = 0.948$; Figure 7.2). Only three marginally flaked specimens were recovered from the Late Paleoindian levels, making interpretations of the relationship between bit convexity and bit angle impossible.

Among those End Scraper specimens produced from blades, a very weakly negative relationship exists between bit convexity and bit angle ($R^2 = 0.019$, $p = 0.722$; Figure 7.3). Specimens with flatter bits tend to have more acute edge angles, a pattern that runs contrary to expectations. However, the sample size is small, the correlation is weak, and the range of values is narrow with most bit angles falling within a spread of only 10 degrees, meaning that this pattern may be more apparent than real.

Each of these plots of bit convexity vs. bit angle suggests that these two attributes did not co-vary, at least not in a simple linear fashion. In other words, changes in these two attributes do not appear to have occurred concurrently. It is possible that one changed more rapidly than the other through the course of resharpening, or that one attribute was emphasized over the other by toolmakers. I will return to a discussion of these possibilities below.



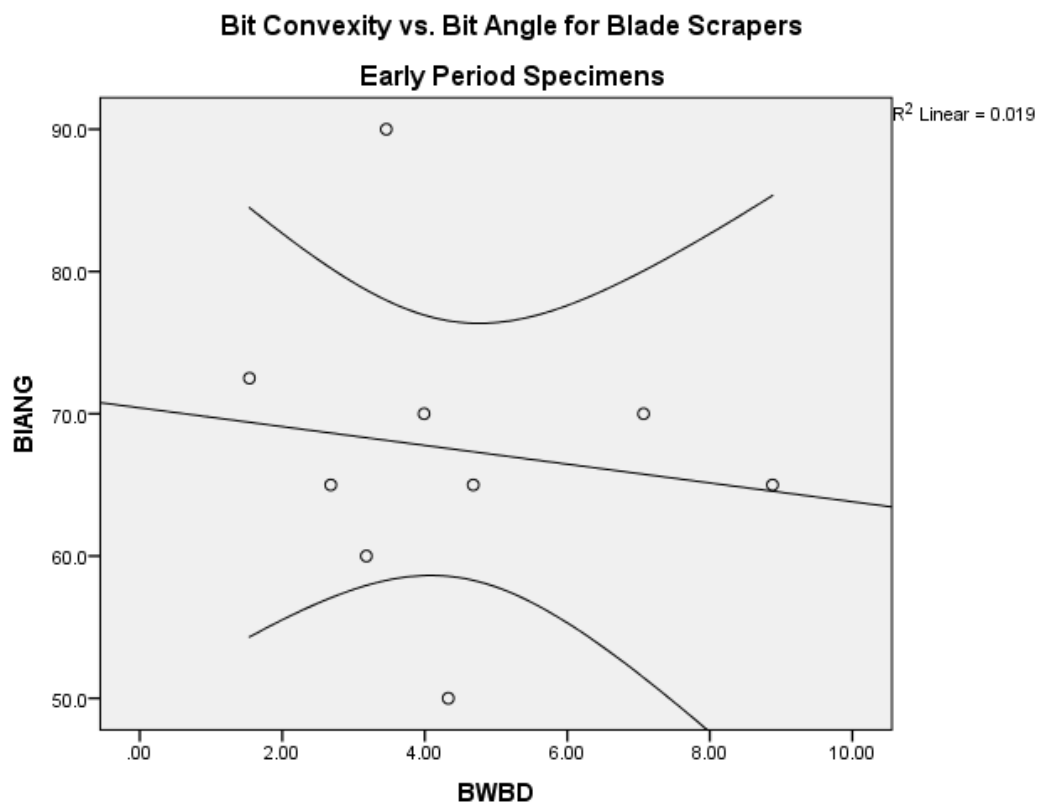
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.006	1	.006	.005	.948 ^b
	Residual	11.572	9	1.286		
	Total	11.578	10			

a. Dependent Variable: BWBD

b. Predictors: (Constant), BIAN

Figure 7.2: Scatterplot of Early Period Dorsally Flaked End Scraper Bit Convexity vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.790	1	.790	.138	.722 ^b
	Residual	40.166	7	5.738		
	Total	40.956	8			

a. Dependent Variable: BWBD

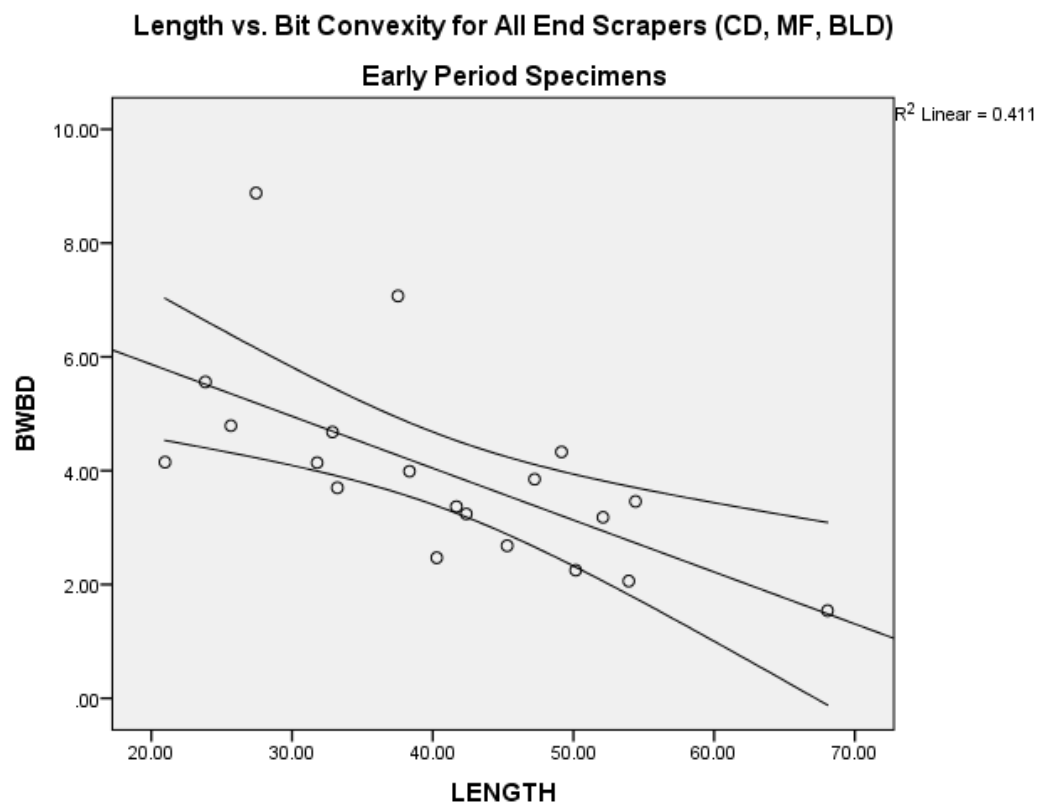
b. Predictors: (Constant), BIAN

Figure 7.3: Scatterplot of Early Period Blade End Scraper Bit Convexity vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

In addition to changes in the bit, successive End Scraper resharpening episodes are argued to reduce tool length over time (Shott 1995: 61-63). It is useful, therefore, to consider these other measures of exhaustion in relation to length. Below, I consider the relationship between tool length and bit convexity, and tool length and bit angle.

A plot of length vs. bit convexity for all Early Period end scrapers indicates that longer tools tend to exhibit more convex bits, while shorter tools tend to possess flatter bits (Figure 7.4). This relationship is a significant one ($R^2 = 0.411$, $p = 0.002$). The pattern noted in this plot conforms to the prediction that End Scraper bits should flatten as they begin to approach the bit-haft juncture as tools are resharpened and become reduced in length. While a simple linear fit line suggests a moderate correlation between these variables, it is possible that the relationship is not, in fact, a simple linear one. In other words tool length and bit convexity might not be expected to co-vary in a simple 1:1 fashion. While tool length may become reduced through resharpening, a tool user may be able to maintain a desired degree of bit convexity through multiple resharpening episodes, as long as sufficient tool length remains. It is, perhaps, not until the tool becomes shortened enough that the bit approaches the juncture with the haft that the bit should begin to flatten. In this case, we would expect to see tool length change more rapidly than bit convexity, to a particular length threshold. Once this threshold is reached, the two variables may begin to change more rapidly in concert with each other.

Dividing the End Scraper sample according to degree of modification, we see that the pattern noted above persists among the dorsally flaked (CD) specimens (Figure 7.5). A significant relationship ($R^2 = 0.695$, $p = 0.001$) exists between length and bit convexity for this sub-sample. Longer tools are associated with more convex bits, while shorter tools tend to have flatter bits.

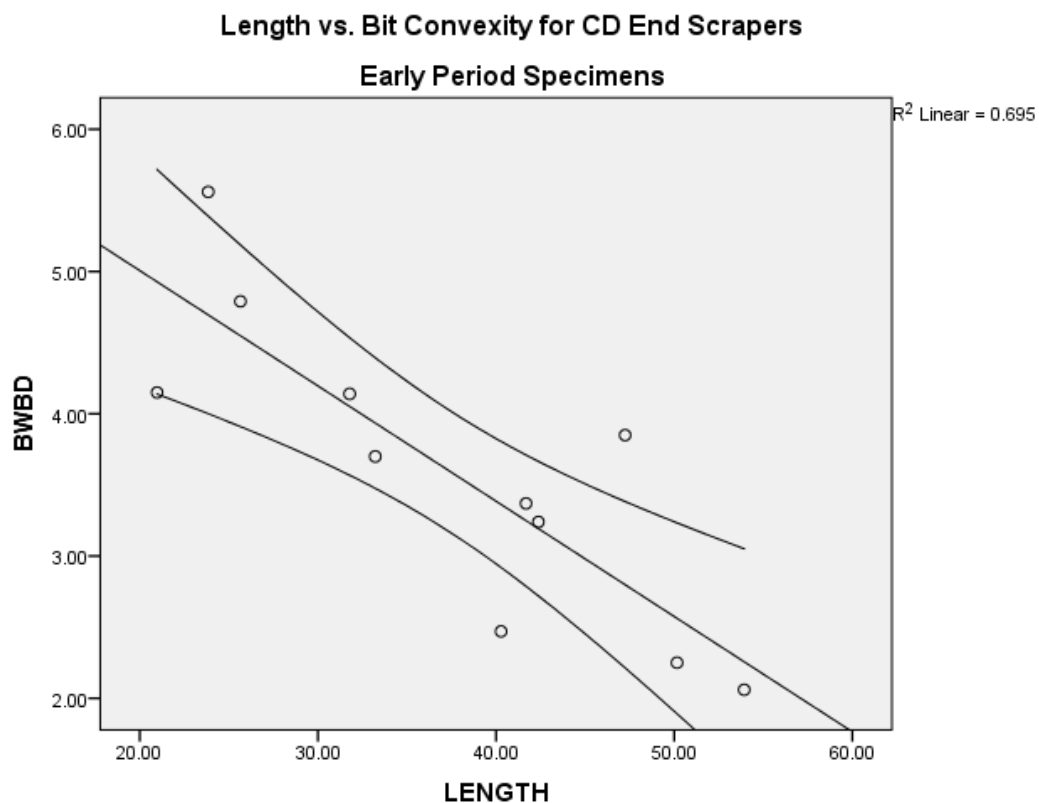


ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1132.409	1	1132.409	12.537	.002 ^b
	Residual	1625.798	18	90.322		
	Total	2758.208	19			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BWBD

Figure 7.4: Scatterplot of Early Period End Scraper Length vs. Bit Convexity. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	851.738	1	851.738	20.524	.001 ^b
	Residual	373.490	9	41.499		
	Total	1225.228	10			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BWBD

Figure 7.5: Scatterplot of Early Period Dorsally Flaked End Scraper Length vs. Bit Convexity. (Primary measurement data available in Appendix A, Table A-3.)

This same relationship is impossible to assess for the marginally flaked (MF) End Scrapers, as only 2 complete specimens were recovered. Both of these items were relatively short (approximately 29-33 mm) and had fairly flat bits (approximately 5.0-5.5) in relation to the measurements of the dorsally flaked specimens.

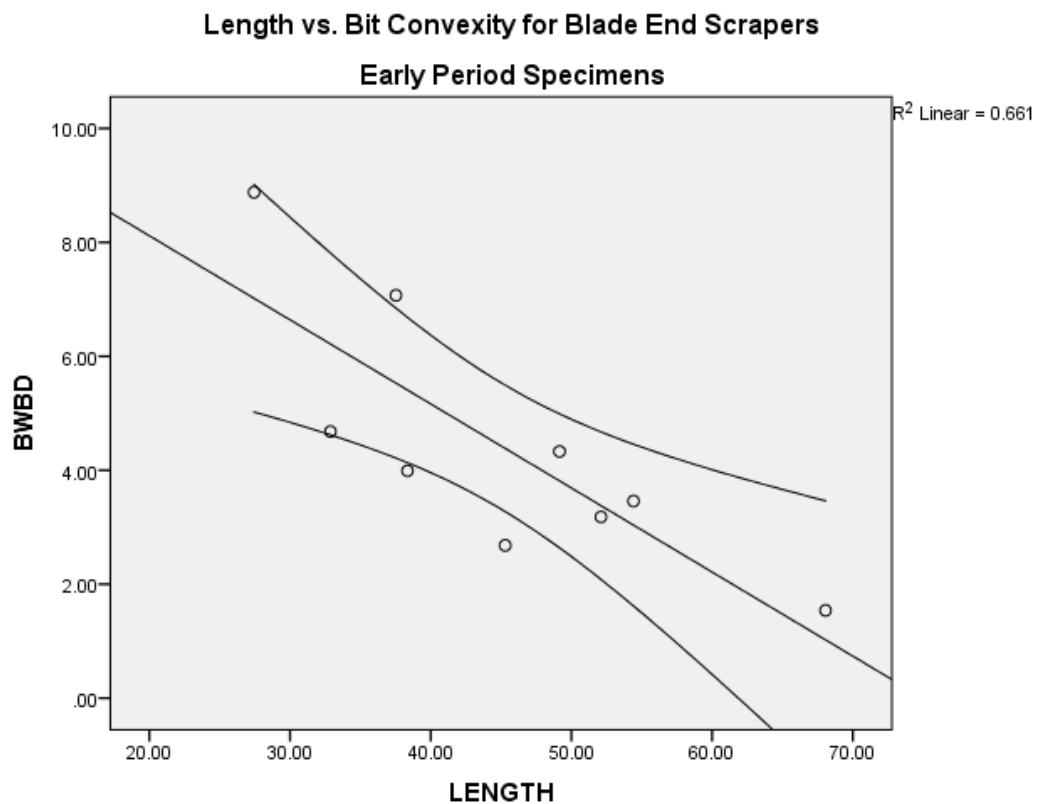
A plot of tool length vs. bit convexity in the sample of Blade End Scrapers exhibits a significant correlation ($R^2 = 0.661$, $p = 0.008$) with a negative slope, suggesting that longer tools have more convex bits, while shorter specimens have flatter bits, conforming to the above expectations (Figure 7.6). Because the sample size is so small, though, the strength of this relationship is dubious.

The following scatterplots, which display the relationship of End Scraper length to bit angle, show that the data from the Early period specimens do not conform to the expectations outlined above. It is suggested that, as tools become reduced in length through resharpening, they should also exhibit progressively steeper bit angles. This is not the pattern that these plots show.

Examination of the sample as a whole shows a positive slope, but the correlation lacks significance ($R^2 = 0.002$, $p = 0.840$), indicating no relationship between length and bit angle (Figure 7.7).

Examining only the dorsally flaked specimens reveals no significant correlation between length and bit angle ($R^2 = 1.229^{-5}$, $p = 0.992$; Figure 7.8).

So few marginally flaked specimens ($n=3$) were recovered that no conclusions regarding the relationship between length and bit angle could be drawn with any certainty.



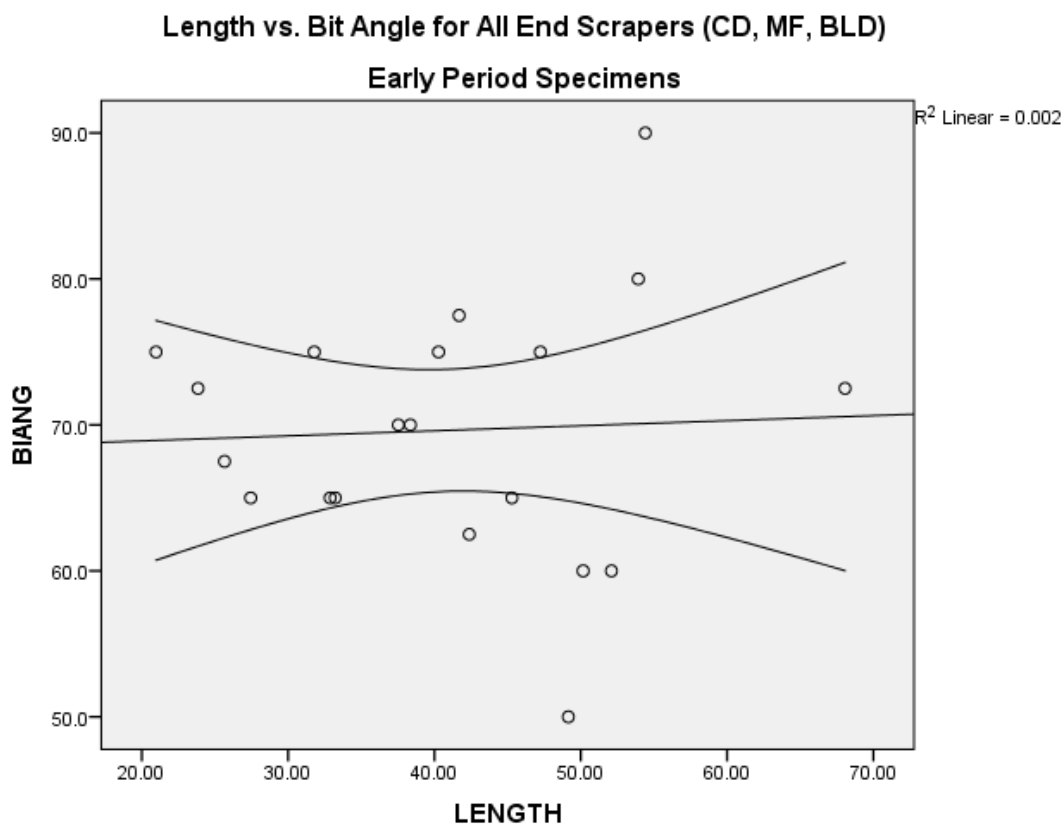
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	822.488	1	822.488	13.674	.008 ^b
	Residual	421.049	7	60.150		
	Total	1243.538	8			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BWBD

Figure 7.6: Scatterplot of Early Period Blade End Scraper Length vs. Bit Convexity. (Primary measurement data available in Appendix A, Table A-3.)



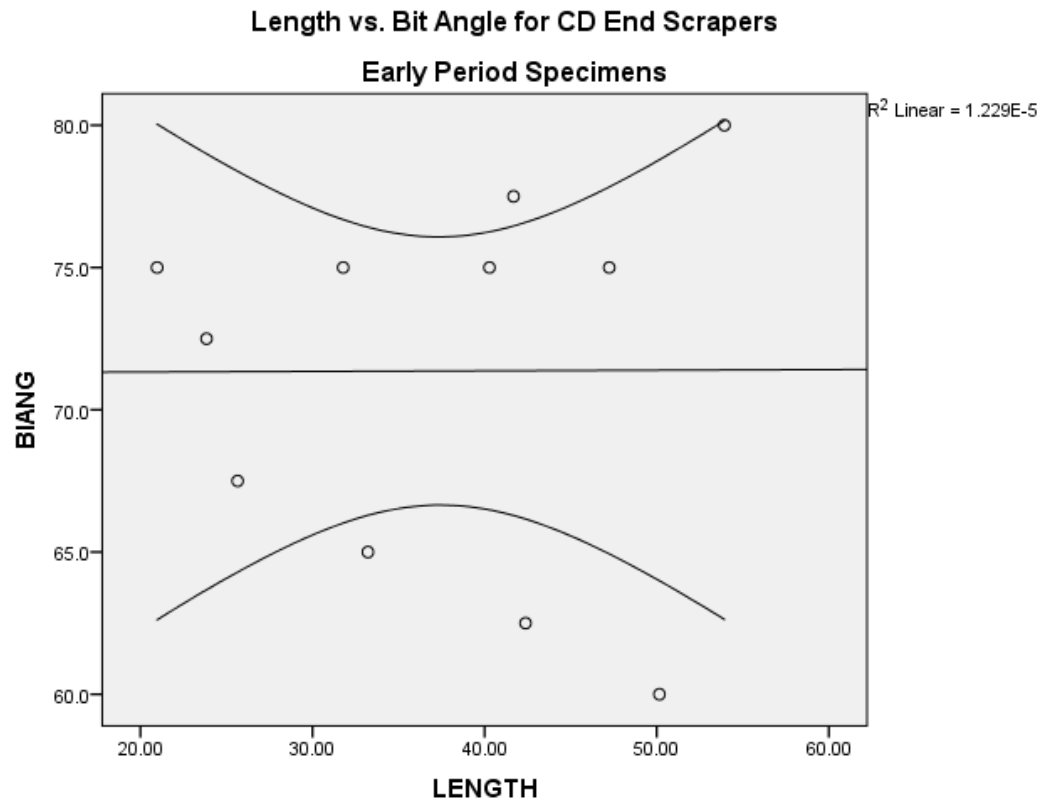
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.405	1	6.405	.042	.840 ^b
	Residual	2751.803	18	152.878		
	Total	2758.208	19			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BIAN

Figure 7.7: Scatterplot of Early Period End Scraper Length vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.015	1	.015	.000	.992 ^b
	Residual	1225.213	9	136.135		
	Total	1225.228	10			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BIANGL

Figure 7.8: Scatterplot of Early Period Dorsally Flaked End Scraper Length vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

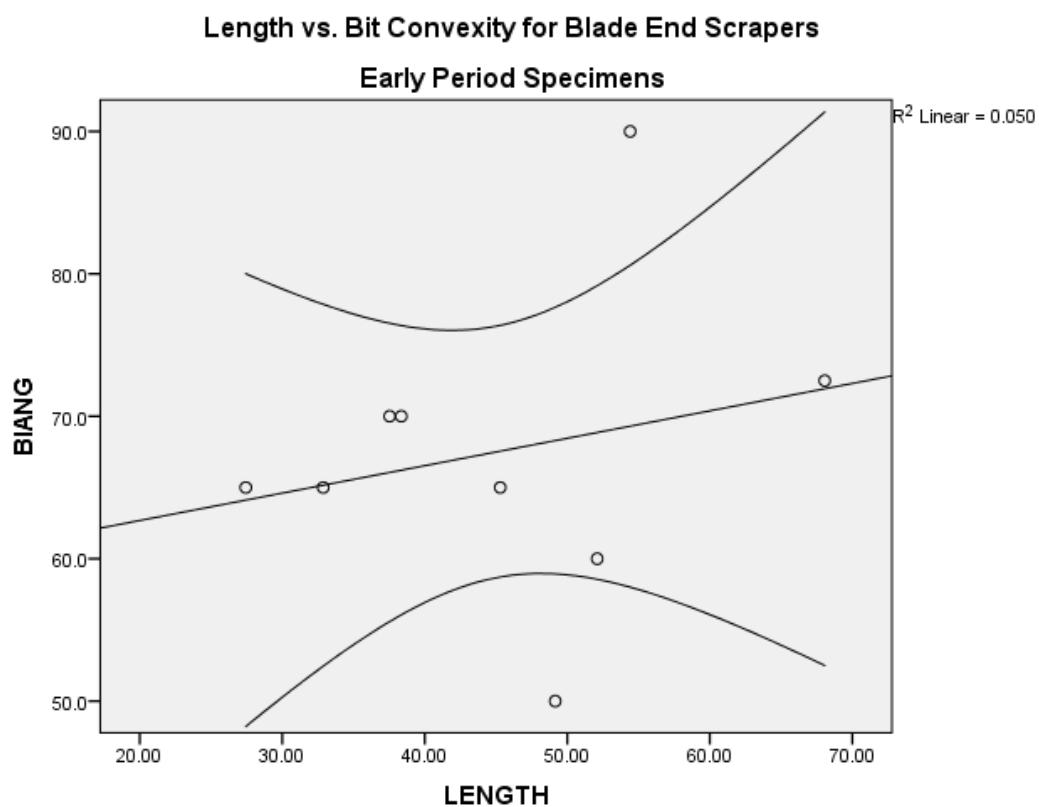
A scatterplot of length vs. bit angle for the Blade End Scrapers (Figure 7.9) shows a relatively weak positive slope, suggesting that longer specimens are associated with steeper bits, but the relationship is not a significant one ($R^2=0.050$, $p = 0.564$). This pattern runs contrary to the expectations I outlined above, but it is important to note that the sample size is small and may, therefore, make it impossible to say anything meaningful about this apparent pattern.

In considering all of these patterns together, it seems that bit angle and bit convexity do not co-vary in a consistent manner through the process of resharpening and the accompanying reduction of the tool. In addition, bit angle does not seem to co-vary with length in the expected manner. Changes in bit convexity, on the other hand, do appear to be related to changes in tool length, at least to some degree.

Mid Period End Scrapers

In examining the relationship between bit convexity and bit angle among the Mid Period End Scraper specimens, we see a weakly positive slope, suggesting that as bits become straighter they also become steeper. In spite of this general trend, this apparent relationship is not a significant one ($R^2 = 0.050$, $p = 0.563$; Figure 7.10).

This same pattern holds when the dorsally flaked specimens. There is an apparent trend toward specimens with flatter bits also possessing steeper edge angles, but the relationship is not a significant one ($R^2 = 0.257$, $p = 0.304$; Figure 7.11). Too few marginally flaked specimens were recovered to allow an assessment of bit convexity in relation to bit angle.

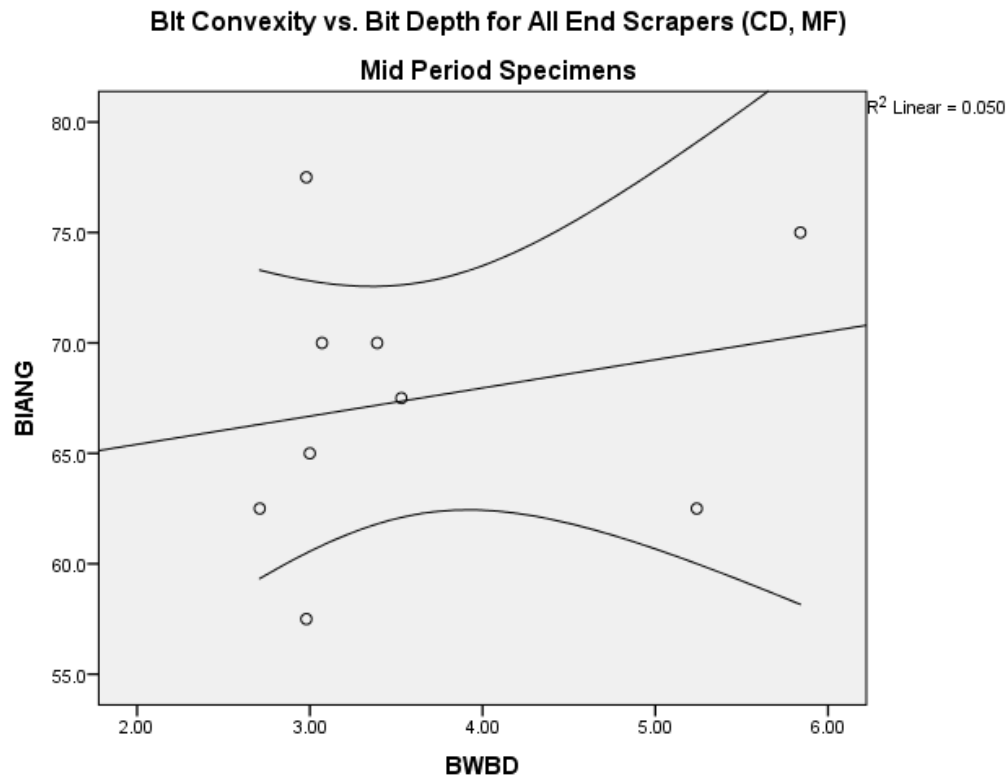


ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	61.933	1	61.933	.367	.564 ^b
	Residual	1181.604	7	168.801		
	Total	1243.538	8			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BIAN

Figure 7.9: Scatterplot of Early Period Blade End Scraper Length vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



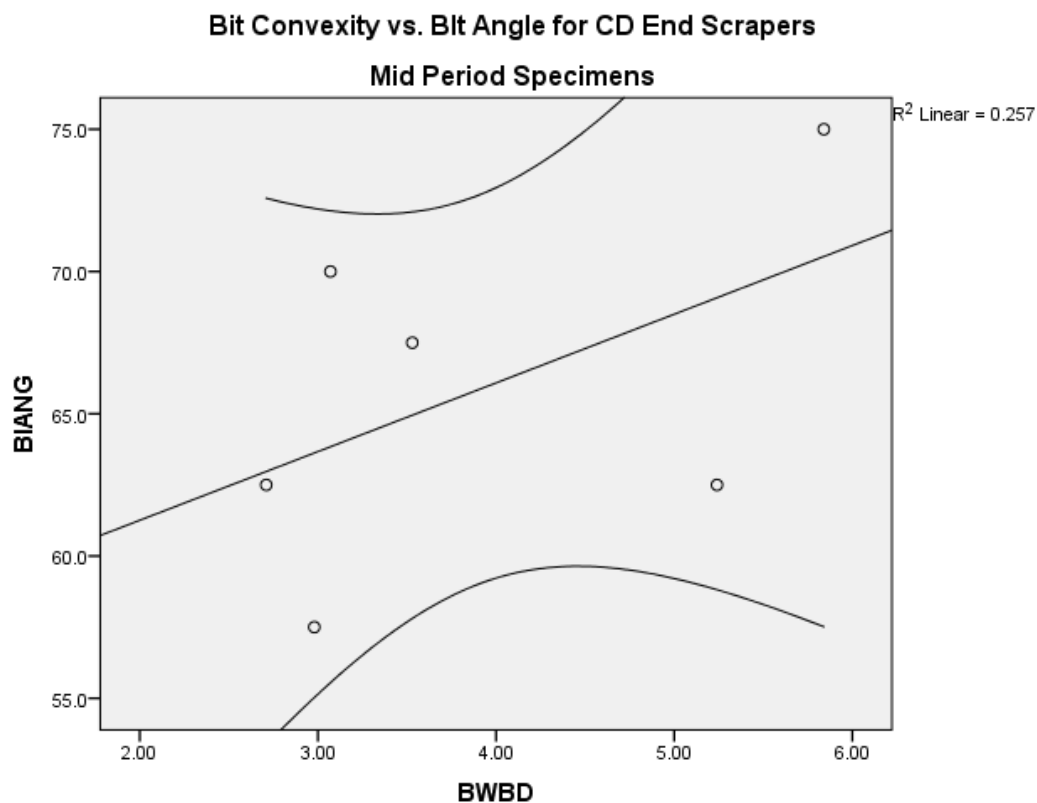
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.496	1	.496	.368	.563 ^b
	Residual	9.449	7	1.350		
	Total	9.945	8			

a. Dependent Variable: BWBD

b. Predictors: (Constant), BIAN

Figure 7.10: Scatterplot for Mid Period end Scraper Bit Convexity vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.225	1	2.225	1.386	.304 ^b
	Residual	6.422	4	1.606		
	Total	8.647	5			

a. Dependent Variable: BWBD

b. Predictors: (Constant), BIAN

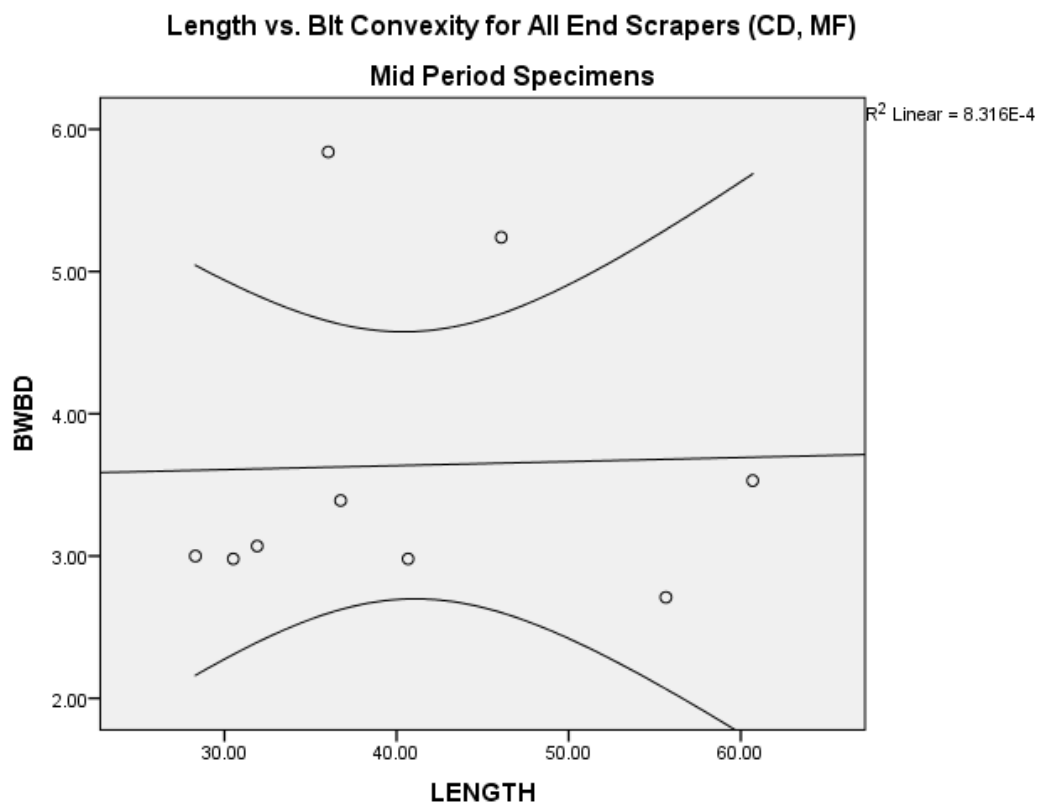
Figure 7.11: Scatterplot for Mid Period Dorsally Flaked End Scraper Bit Convexity vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

Considering length vs. bit convexity in the Mid Period specimens, we see a very weakly negative relationship ($R^2 = 8.316^{-4}$, $p = 0.941$; Figure 7.12), which suggests that longer tools tend to have more convex working edges, and shorter tools have straighter bits. This pattern corresponds to my expectations of decreasing bit convexity through reduction.

The dorsally flaked specimens show a weak negative relationship ($R^2 = 0.015$, $p = 0.941$), which suggests that longer tools tend to exhibit more convex bits, although the correlation is not statistically significant (Figure 7.13).

The relationship between length and bit convexity for the marginally flaked end scrapers could not be assessed because of the small sample size.

A single specimen made on a blade was recovered from these levels. In comparison to specimens made on other blank types, this individual blade scraper was moderate in length (49.5 mm), with a relatively straight bit (BW:BD = 4.17). Its bit angle was much more acute than the angles seen on any other specimens (47.5°). The relatively straight bit, as indicated by the high bit width-to-depth ratio might suggest a more advanced stage of tool exhaustion, but the very acute bit angle suggests, instead, an earlier stage in its use history. Another possibility is that this particular implement, while morphologically similar to an End Scraper, was instead being used for another task.

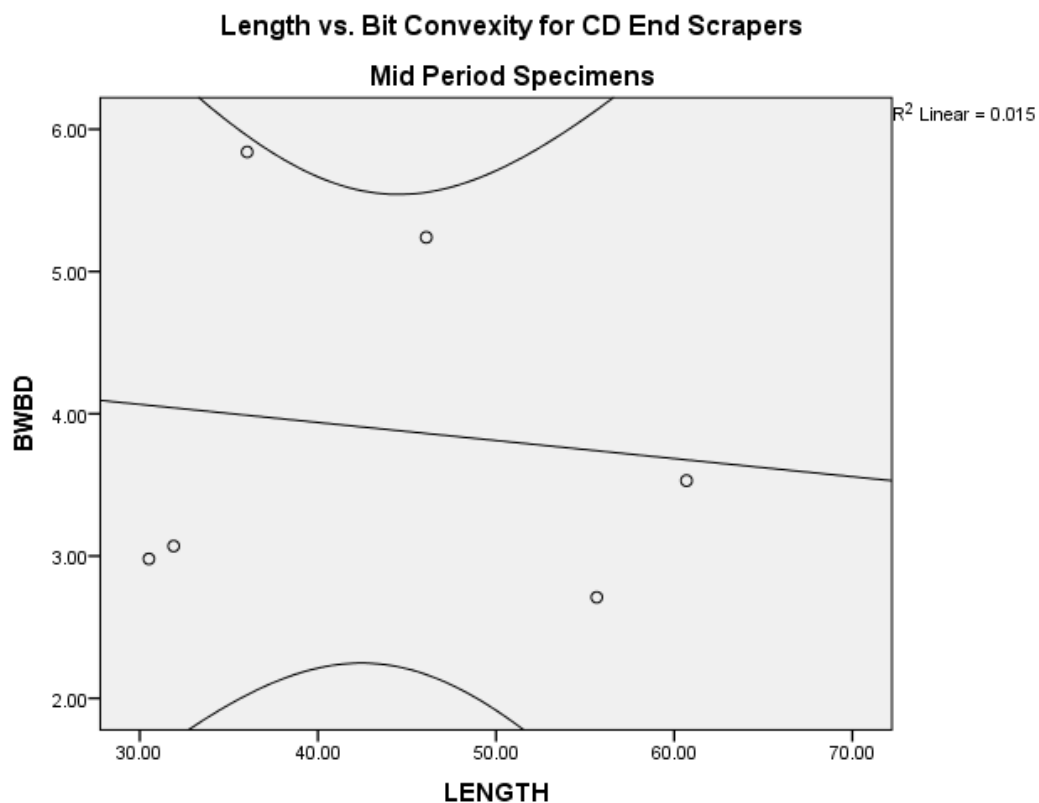


ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.852	1	.852	.006	.941 ^b
	Residual	1023.386	7	146.198		
	Total	1024.238	8			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BWBD

Figure 7.12: Scatterplot for Mid Period End Scraper Length vs. Bit Convexity. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.210	1	12.210	.061	.817 ^b
	Residual	796.663	4	199.166		
	Total	808.873	5			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BWBD

Figure 7.13: Scatterplot for Mid Period Dorsally Flaked End Scraper Length vs. Bit Convexity. (Primary measurement data available in Appendix A, Table A-3.)

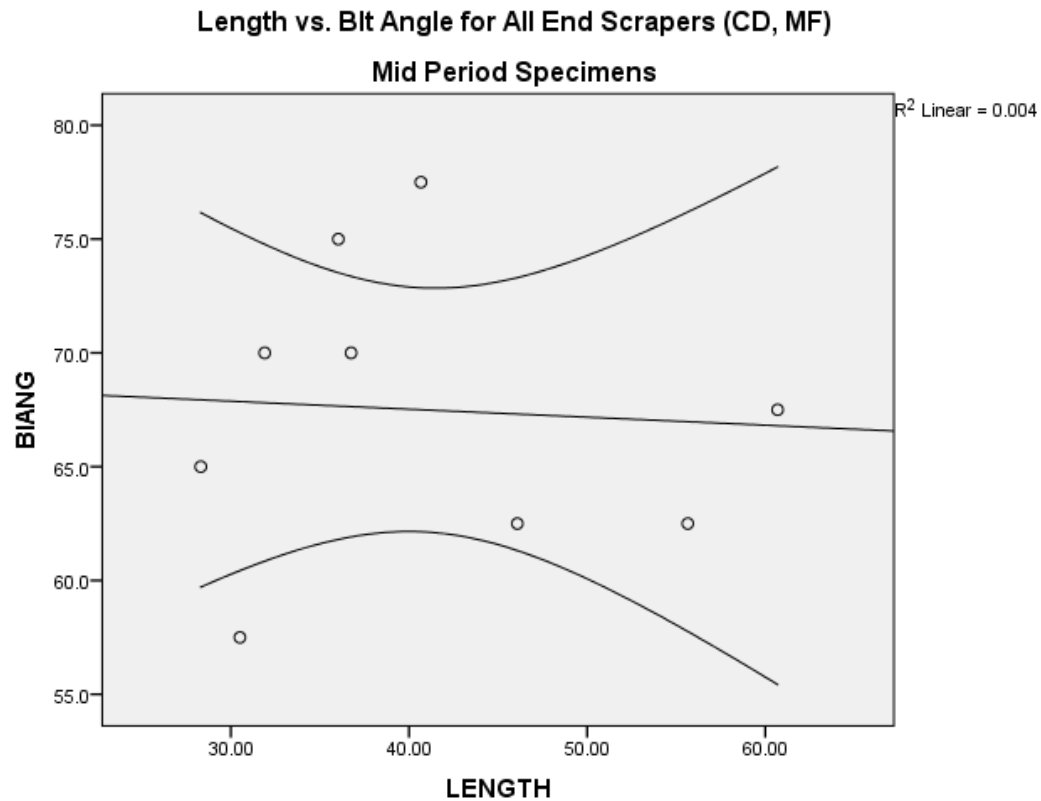
A consideration of the measures of length vs. bit angle for all Mid Period End Scrapers (Figure 7.14) shows a weakly negative relationship between these variables, but one that is not statistically significant ($R^2 = 0.004$, $p = 0.873$). This suggests that longer tools exhibited more acute edge angles, while shorter tools possessed steeper edge angles. While this pattern conforms to general expectations, the correlation is so weak as to be largely uninformative. The relationship appears to be much more diffuse, suggesting discard of these implements at various points in their use lives. With a slight clustering of tools around 30-40 mm in length, perhaps a minimum length threshold more than the achievement of a certain edge angle was the factor that governed discard.

The weak association of length and bit angle persists when only the dorsally flaked specimens are examined (Figure 7.15), suggesting again that the coincidence of these two variables may not have been an important factor in the decision to discard ($R^2 = 0.005$, $p = 0.891$).

Consideration of the minimally flaked End Scrapers was impossible because of the small sample size.

Late A Period End Scrapers

So few specimens were recovered from the Late A period that it is difficult, if not impossible, to draw any conclusions based on examination of the scatterplots. Only three minimally flaked scrapers and one dorsally flaked specimen were recovered, so splitting the data according to degree of modification will not reveal any significant patterns. Only very general trends can be seen in the measurements, and these likely are meaningless, given the small samples.



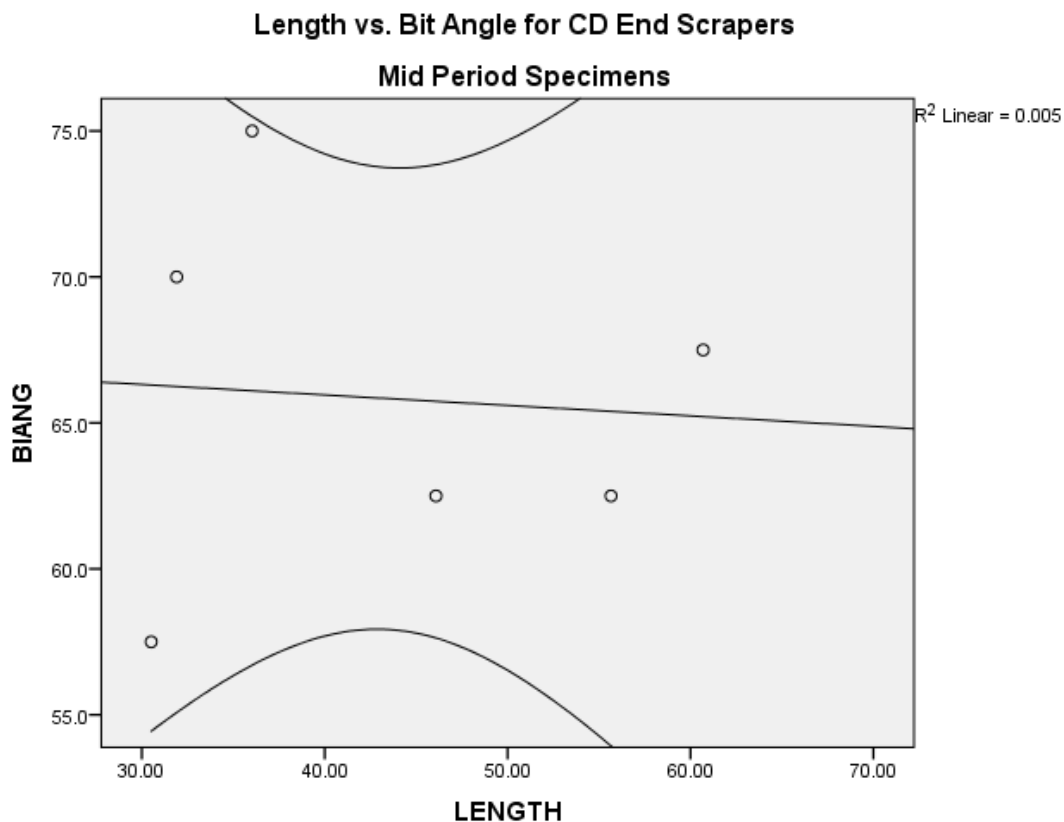
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.982	1	3.982	.027	.873 ^b
	Residual	1020.256	7	145.751		
	Total	1024.238	8			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BIAN

Figure 7.14: Scatterplot for Mid Period End Scraper Length vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.297	1	4.297	.021	.891 ^b
	Residual	804.576	4	201.144		
	Total	808.873	5			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BIAN

Figure 7.15: Scatterplot for Mid Period Dorsally Flaked End Scraper Length vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

The End Scraper data discussed above show, quite consistently, that changes in bit convexity and bit angle through successive resharpening episodes do not appear to have occurred concurrently or at the same rate. When these two indicators of reduction are considered in association with changes in tool length, little correlation is noted between bit angle and tool length. Instead, the only strong relationship appears to exist between changes in tool length and changes in bit convexity. With the exception of the fairly direct relationship between length and bit convexity, expectations regarding changes in End Scraper attributes through their use lives were not met. It is suggested that the explanation for this lack of conformity to these expectations rests in the timing and speed of the changes in these variables.

If tools are sufficiently long at the beginning of their use lives, they may be resharpened repeatedly before the bit encroaches on the haft and the tool becomes impossible to rejuvenate. As discussed above, when the bit begins to approach the haft, bit convexity diminishes as material continues to be removed from the apex of the bit but not from the corners. So, while tool length will change fairly consistently throughout the use-life of the implement, bit convexity will not begin to change significantly until nearer to the end of the tool's life. Changes in bit angle, on the other hand, may be initiated earlier in the life history of the tool. As suggested earlier, the removal of resharpening flakes may alter the angle of the worked edge. These changes may begin almost immediately when resharpening flakes are removed. These changes can occur before tool length becomes shortened enough that the bit begins to encroach on the haft. This may explain the lack of correspondence between changes in bit convexity and changes in bit angle among the End Scrapers.

Maintaining a particular bit angle may have been of less concern to tool users than simply maintaining a sharp edge (Comstock 2011; Seeman et al. 2013). Sharp stone edges become

dulled through use, therefore having enough tool length to allow as large a number of potential resharpening episodes as possible may have been paramount in the design of these implements. Seeman et al. (2013: 426) have argued that results of their experimental studies suggest that “distal retouch angles of 50 degrees work just about as well as end scrapers with edge angles of 80 degrees in either in-line or elbow hafts” and that “Successfully completing a long series of resharpenings using percussion was probably more important than achieving a narrowly specified target angle.” Ethnographic observations (e.g., Osgood 1940: 80) as well as experimentation (e.g., Seeman et al. 2013: 428) have shown that a single hide may be scraped by a single scraper, provided that the tool begins its use life with sufficient length (approximately 50-55 mm) to allow from seven to ten resharpening episodes. These requirements may be less stringent if tools were being used on residential sites, where tool replacement would have been easier (e.g., Bamforth 1991: 368; Kuhn 2004: 433). The longest complete or relatively complete specimens in the Dust Cave sample approach 70 mm in length, giving ample opportunity for resharpening, according to these predictions.

Because the sample includes complete specimens that are both long with convex bits and short with flat bits, we must think about when these implements were being discarded, and under what circumstances. The presence of less heavily used and more heavily used specimens on the site suggests that they were not simply being discarded as soon as maximum utility had been extracted. The paucity of deer bone on-site during the Early period, when End Scrapers were so common in the tool assemblage, suggests that processing was occurring off-site. These End Scrapers may have been used elsewhere and returned to Dust Cave for retooling, being discarded either when broken, completely exhausted, or after having been used and resharpened enough times that their potential for greatest number of rejuvenation episodes had diminished. For

mobile hunter gatherers who travel and work away from the locations of raw material extraction and tool production, having a thoroughly replenished toolkit with great potential for reuse and rejuvenation is of utmost importance, in order to meet the often unpredictable demands of a mobile lifestyle.

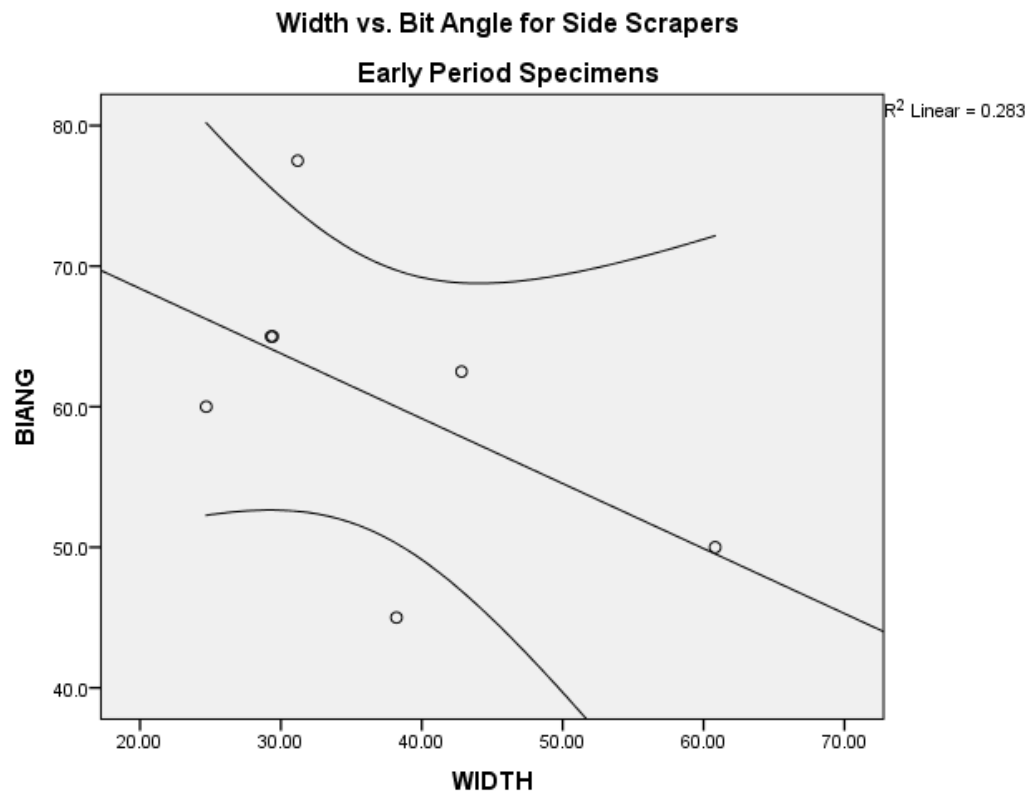
Side Scrapers

Most tools discussed here were produced on blanks other than blades. Only three Blade Side Scrapers were recovered from the early period, and these are presented at the end of this section. Unlike the End Scrapers, discussed above, Side Scrapers exhibit working edges along the lateral margins of the tools. Resharpening of these implements would have resulted in a greater reduction of tool width than tool length. Tools that have experienced more intensive resharpening should, therefore, exhibit narrower blades in relation to their lengths. Length likely remained relatively unaltered through episodes of use and resharpening, barring breakage of the tool, or removal of some material from specimens whose functional edges converged at the distal end. While it is possible that edge angle could have become steeper through successive resharpening episodes, the toolmaker might easily have maintained the desired working angle by removing flakes at a more acute angle. Edge angles may have become steeper once the tool reached a particular width threshold, beyond which it may have been deemed too narrow to withstand the pressures applied during use (i.e., so narrow as to become prone to breakage).

It is difficult to assess the width of tools in relation to their lengths, as the sample contains many broken specimens and so few complete specimens as to make interpretations statistically unsound. So, rather than consider other variables in relation to length, I focus on the relationship of other variables to tool width, which should become reduced through resharpening.

While width may be more apt to be a useful measure of change in these specimens, it is important to remember that starting widths may not have been consistent on all specimens, so determining degree of width reduction may be problematic. Plenty of formulae have been devised for determining blank dimensions (Davis and Shea 1998; Dibble and Pelcin 1995; Dibble and Whittaker 1981; Pelcin 1998; Shott et al. 2000; Speth 1974, 1981). Many of these formulae consider length and thickness, rather than width, and refer to *blank* dimensions rather than *tool* dimensions. Blank dimensions can be altered through transformation into a tool, rendering such formulae useless for assessing tool size. In addition, most of these formulae depend on knowing platform dimensions. This sample of tools contained many fragments that did not retain their platforms, making it impossible to even consider original blank size.

An examination of bit angle in relation to tool width shows a negative relationship, suggesting that wider tools tend to have more acute bit angles, while narrower specimens tend to have steeper working edges ($R^2 = 0.283$, $p = 0.219$; Figure 7.16). This pattern appears to conform to the expectation that tools that have undergone successive episodes of resharpening might exhibit a reduction in width and an increase in bit angle, although the correlation is not significant. This relationship may still be somewhat misleading, as not all specimens will have begun with the same width. In other words, a “narrow” specimen may have been narrow initially, rather than becoming narrow through resharpening.



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	255.353	1	255.353	1.970	.219 ^b
	Residual	648.213	5	129.643		
	Total	903.566	6			

a. Dependent Variable: WIDTH

b. Predictors: (Constant), BIAN

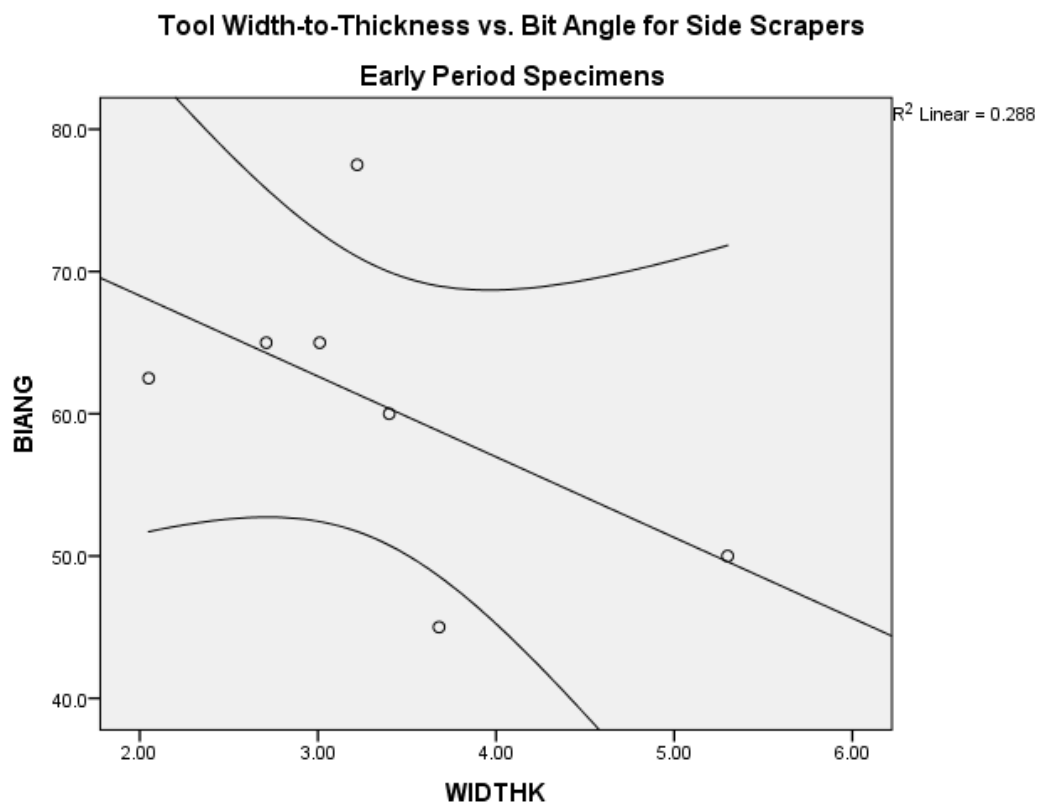
Figure 7.16: Scatterplot for Early Period Side Scraper Width vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

With the exception of a single outlier, width-to-thickness ratios are quite narrowly spread (2.0-3.5), especially in comparison to the spread of bit angle or width alone, discussed above (Figure 7.17). This narrow range of values may indicate that this ratio was an important factor in the decision to discard. Tools that became too narrow compared to thickness might have been prone to breakage during use. Width-to-thickness may, therefore, have been a greater concern in the decision to discard than were edge angles, which varied widely from approximately 45° to almost 80°.

Only one specimen was recovered from a zone other than the Early period zones. This one tool, from Zone K, was narrow relative to the widths of the Early specimens, and exhibited a steep bit angle of 70°. This one specimen conformed to the expected pattern of blade narrowing and increased bit angle, which was also seen in the Early period sample.

Only three Blade Side Scrapers were recovered from Dust Cave, and all of these were located in the Early zones. As was the case for the Side Scrapers produced from other blank types, I suggest that Blade Side Scraper tool width may have become reduced through resharpening, and working edge angles may also have become steeper. Unfortunately, given the small sample size, no strong conclusions could be drawn.

The sample of Blade Side Scrapers is too small to allow any interpretations to be made about the importance of various attributes in the decision to discard. The range of bit angles represented is much narrower than that seen among the Side Scrapers produced from other blank types (approximately 52° to 65°), while the widths and width-to-thickness ratios show a much greater range of values. Widths vary across nearly a 50 mm spread, while width-to-thickness ratios vary widely from less than 3.0 (moderately narrow) to nearly 7.5 (very wide). While the sample size is so small that we cannot put much stock in these trends, they suggest a different



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.773	1	1.773	2.027	.214 ^b
	Residual	4.373	5	.875		
	Total	6.145	6			

a. Dependent Variable: WIDTHK

b. Predictors: (Constant), BIAN

Figure 7.17: Scatterplot for Early Period Side Scraper Tool Width-to-Thickness vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

pattern from those seen among the other Side Scrapers: the narrow range of bit angles hints that this attribute may have been of at least some concern in the decision to discard. Functional differences between these Blade Side Scrapers and those made on other blank types is one possible explanation for these patterns, and will be considered in the following chapter.

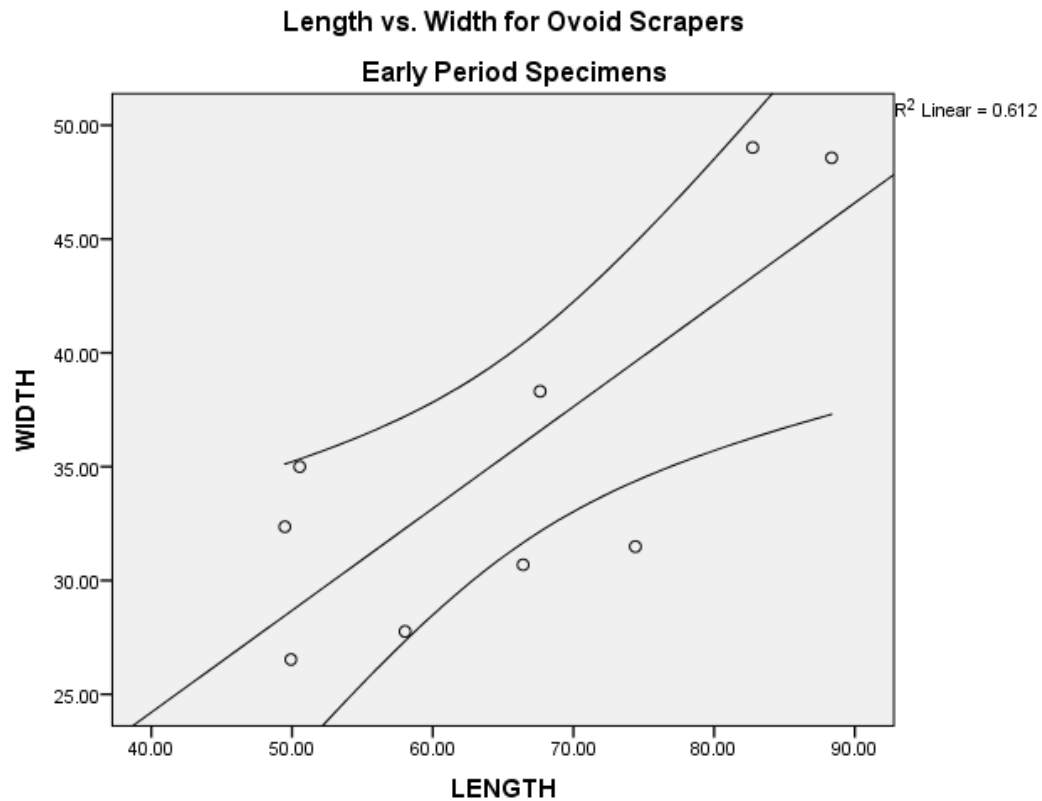
Ovoid Scrapers

Ovoid Scrapers are quite similar in some ways to Side Scrapers with the exception that marginal modification extends around the entire circumference of the tool, rather than being restricted only to the lateral margins. While these tools exhibit secondary flaking along the distal end of the blank, there is no reason to suspect that they were being used in a manner similar to the End Scrapers. These implements do not exhibit the same distinctive distal morphology as seen among the End Scrapers, nor the same evidence for concentrated wear and resharpening at the distal end. Instead, these tools were being flaked and resharpened fairly evenly around the circumference. Like the Side Scrapers, they appear to have had slightly more acute working edges than the steep bits seen among the End Scrapers. This may suggest that their intended function was as cutting rather than scraping implements, a possibility that will be considered further in the discussion of tool function (Chapter 8).

Because of the morphological similarities between these tools and the Side Scrapers, it is expected that similarities would exist in the presence of certain traces of use and resharpening. As with the Side Scrapers, my expectation is that Ovoid Scrapers would become narrower throughout the course of use and resharpening and that they might exhibit an increase in edge angles as edges were resharpened. Because these implements were modified around their entire circumference, though, the expectation is that material would also have been removed from the

distal end, thereby reducing length as well as width. These tools should therefore have become smaller overall through the course of resharpening.

Almost all of the Ovoid Scrapers recovered were complete or relatively complete, making assessments of their degrees of reduction much simpler and potentially more informative. An examination of tool length and width shows that shorter specimens tend to be narrower, while longer specimens tend to be wider ($R^2 = 0.612$, $p = 0.013$ Figure 7.18). This pattern could represent the effects of resharpening or could indicate original blank size. In other words, the sample of blanks may have been variable in size initially. If this were the case, it would not be surprising to see longer blanks being larger overall (i.e., long and wide) and shorter blanks being smaller overall (i.e., short and narrower in comparison to the longer specimens). Considering edge angle in relation to length and width we see conflicting and weak patterns. If the assumptions presented regarding tool changes during the course of resharpening are correct, then the expectation would be for shorter, narrower tools associated with steeper edge angles. A plot of length vs. edge angle shows that longer tools seem to be associated with more acute edge angles, while shorter tools exhibit steeper edge angles ($R^2 = 0.119$, $p = 0.364$ Figure 7.19). This pattern conforms to expectations, although the relationship does not appear to be a significant one. Plotting width against bit angle, on the other hand, suggests that wider tools seem to have slightly steeper edge angles, a pattern that runs contrary to expectations (Figure 7.20). However, the R^2 value of 0.017 indicates that this apparent association is an extremely weak one, and one that is not statistically significant ($p = 0.736$).

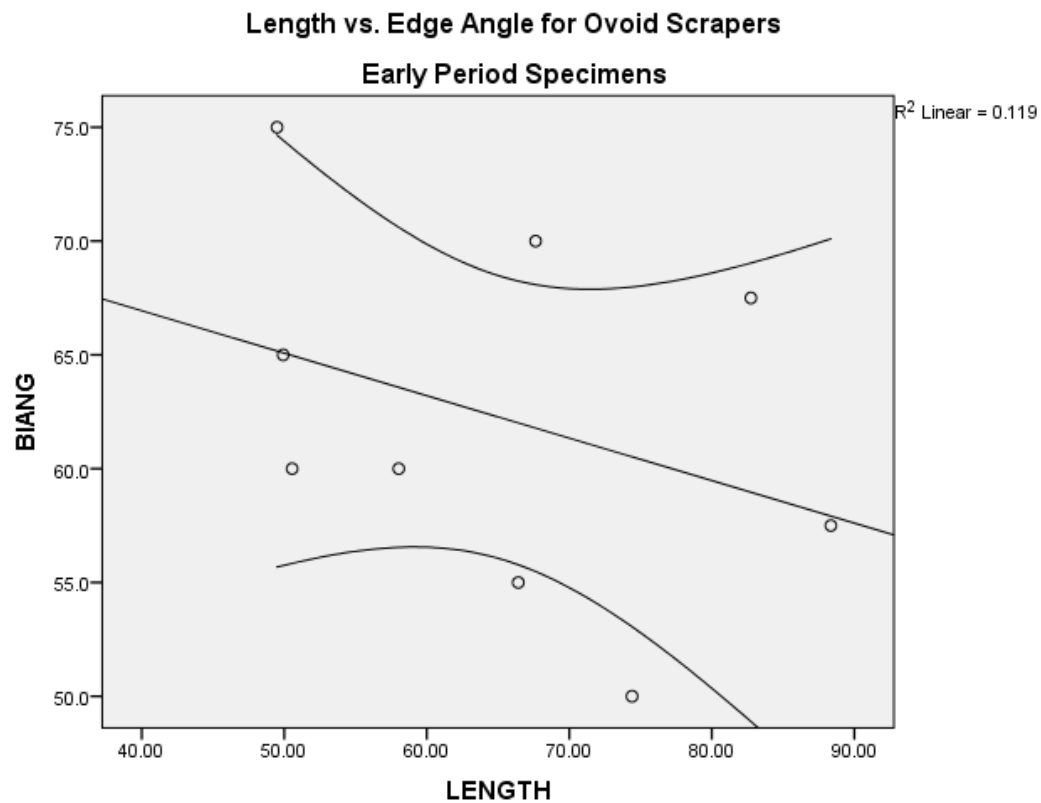


ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1028.606	1	1028.606	11.022	.013 ^b
	Residual	653.256	7	93.322		
	Total	1681.862	8			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), WIDTH

Figure 7.18: Scatterplot for Early Period Ovoid Scraper Length vs. Width. (Primary measurement data available in Appendix A, Table A-3.)



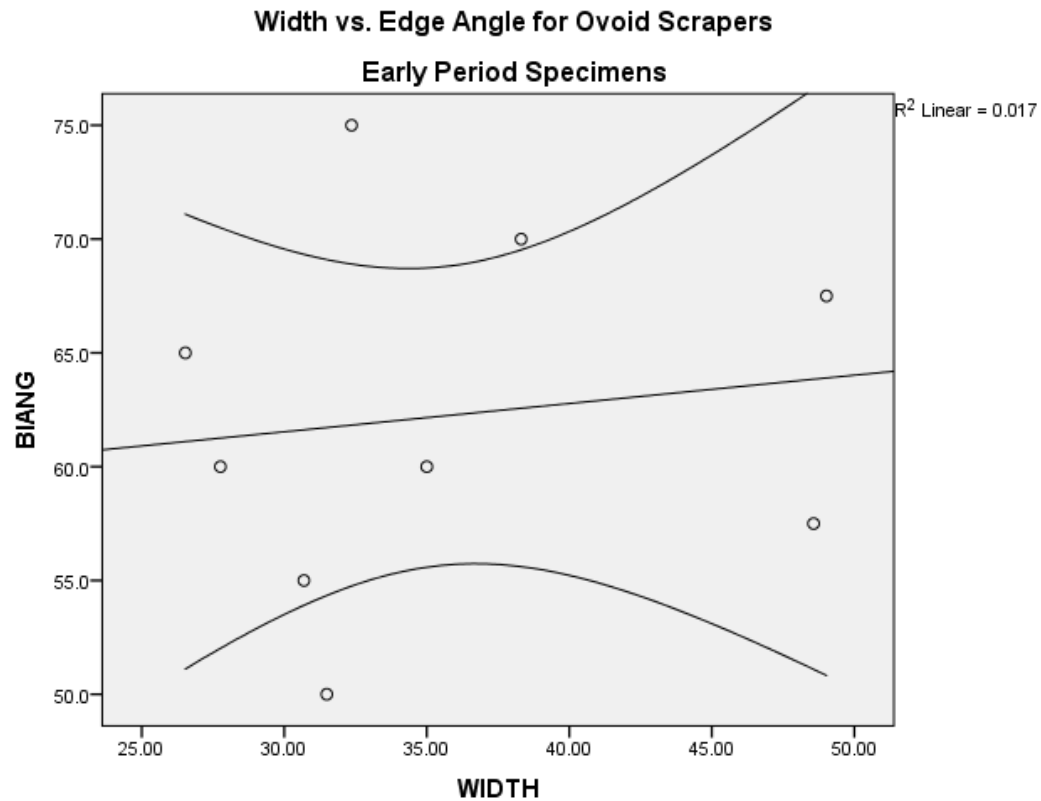
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	199.711	1	199.711	.943	.364 ^b
	Residual	1482.151	7	211.736		
	Total	1681.862	8			

a. Dependent Variable: LENGTH

b. Predictors: (Constant), BIAN

Figure 7.19: Scatterplot for Early Period Ovoid Scraper Length vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.521	1	9.521	.123	.736 ^b
	Residual	541.679	7	77.383		
	Total	551.200	8			

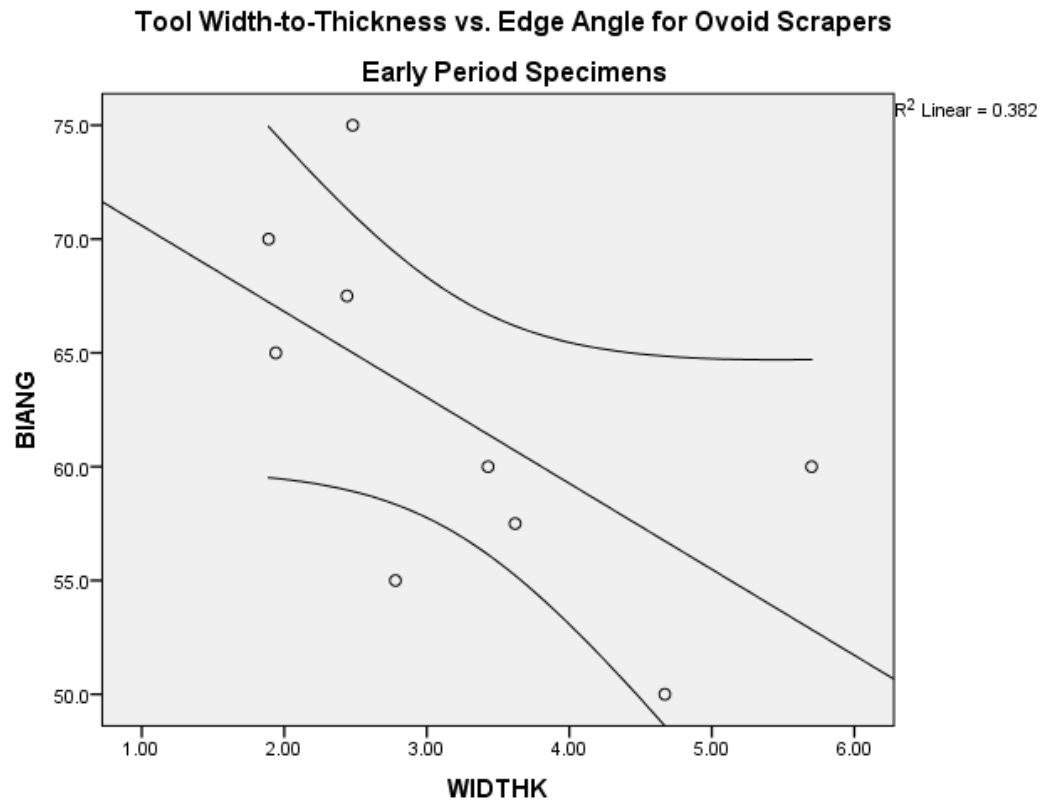
a. Dependent Variable: WIDTH

b. Predictors: (Constant), BIAN

Figure 7.20: Scatterplot for Early Period Ovoid Scraper Width vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

It is likely that the contact areas on these tools were primarily along the edge margins, as their distal edges are not configured in the same way as those of the End Scrapers. In this case, it is these lateral margins where we should expect to see the most wear occurring. Edge margins should therefore be the locations of most intensive resharpening. Greater amounts of reduction in tool width compared to tool length, as well as a corresponding increase in edge angle through progressive resharpening episodes, should therefore be expected for these tools. Tool thickness, on the other hand, likely would have remained essentially unaltered. Examining tool width relative to tool thickness may, therefore, enlighten us about the degree of resharpening experienced by these implements, especially when considered in conjunction with measures of working edge angle. Figure 7.21 displays the width-to-thickness ratio of the Ovoid Scrapers in relation to their working edge angles. This plot indicates that the tools that are wider in comparison to their thicknesses also tend to have more acute edge angles. These patterns are suggestive of lesser degrees of resharpening. On the other hand, tools that are narrower in comparison to their thicknesses tend to be associated with steeper edge angles, suggesting greater degrees of resharpening. With an R^2 value of 0.382, this relationship is a moderately strong one, but one that is just shy of significance ($p = 0.076$).

Considering overall tool size or configuration, measured as a ratio of length to width, reveals a much stronger relationship ($R^2 = 0.515$, $p = 0.030$) to working edge angle than if we examine each attribute individually (Figure 7.22). The relationship is a negative one, suggesting that tools that are longer compared to their widths have more acute edge angles, while tools that are shorter compared to their widths have steeper edge angles. This pattern is somewhat surprising. The expectation was that those tools with blades that were wider relative to their lengths would have been less intensively resharpened and therefore would have exhibited more



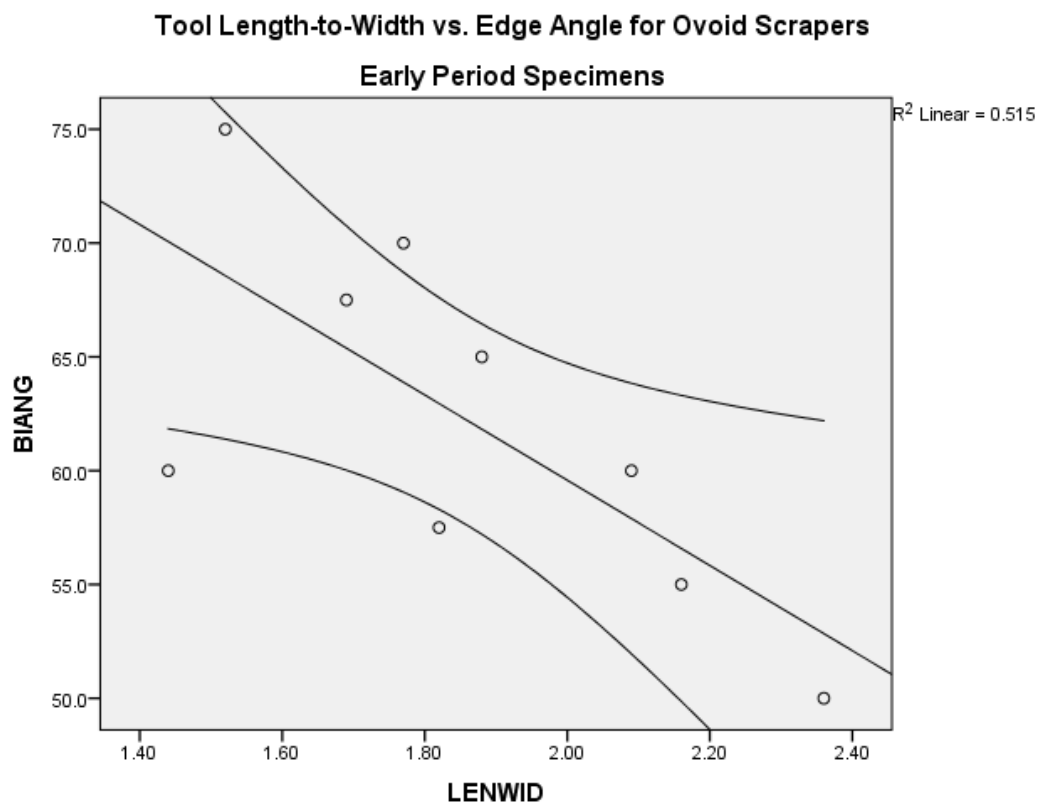
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.047	1	5.047	4.326	.076 ^b
	Residual	8.167	7	1.167		
	Total	13.214	8			

a. Dependent Variable: WIDTHK

b. Predictors: (Constant), BIAN

Figure 7.21: Scatterplot for Early Period Ovoid Scraper W:T Ratio vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)



ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.373	1	.373	7.422	.030 ^b
	Residual	.351	7	.050		
	Total	.724	8			

a. Dependent Variable: LENWID

b. Predictors: (Constant), BIAN

Figure 7.22: Scatterplot of Early Period Ovoid Scraper L:W Ratio vs. Bit Angle. (Primary measurement data available in Appendix A, Table A-3.)

acute edge angles. Perhaps the concurrent changes in tool dimensions are a better indicator of reduction than are changes either in length or width individually. It is likely that a minimum width threshold existed, beyond which these long and narrow tools could not be resharpened successfully. This threshold may have been reached well before tools could no longer be reduced successfully along their lengths. While it was anticipated that most wear would have occurred along the lateral margins, it is possible that under particularly extensive resharpening some material may also have been removed from the distal end, where the converging lateral margins met. These angled margins would have provided a long portion of usable edge length that could have been resharpened repeatedly, resulting in the removal of greater amounts of length over the life of the tool.

Another explanation for these patterns is that, like the End Scrapers, perhaps edge sharpness was more important to the completion of tasks in which these tools were used than was maintenance of a particular edge angle. In this case, the potential for multiple resharpening episodes would have been a key consideration in tool design and discard. Functional differences in Ovoid Scrapers with different edge angles might also provide an explanation, and will be considered in the following chapter.

Only two specimens were recovered from the Mid levels, making assessment of any patterning impossible.

Among the Early period specimens, the ranges of edge angles, widths, and width-to-thickness ratios are relatively wide, suggesting that discard of these implements may have been occurring at a variety of stages in the use sequence. One possible explanation for the varied discard patterns is that these tools may have been used only on-site. With no evidence for hafting modifications, these tools may not represent curated implements. These tools could have been

produced, as needed, from easily transported and easily modified large blanks, such as the blade blanks that appear common in the Early period sample. This explanation is not entirely satisfying, though, as they received fairly substantial investment in their post-detachment modification. Investing such degrees of time and energy in their production does not make sense for tools that were only to be used briefly on-site, where raw materials were plentiful. Another possible explanation for this pattern is that these tools were being left on-site for use upon return to the cave, but no direct evidence for lithic caching is noted at the site. A third possibility is that these specimens represent tools that were used while the Dust Cave population was away from the site, and that they were returned to the cave and abandoned there as part of retooling behavior, with specimens being discarded as they approached the end of their utility. While at the site, toolmakers could have produced new Ovoid Scrapers or could have manufactured transportable flakes for transformation into these and other tool types during forays elsewhere on the landscape. The Ovoid Scrapers certainly would have been useful general-purpose tools that could have been produced, for a range of uses, while away from the site, especially from easily transformed blanks such as blades. Investment in their production/post-detachment modification may have ensured their continued utility, facilitating resharpening throughout the subsistence cycle until toolmakers could return to the cave for retooling.

The Ovoid Scrapers may have been fairly general-purpose tools, with edge angles suggestive of cutting rather than scraping. Microwear analysis, discussed in the following chapter, suggests that these implements were used for cutting. It is likely that a minimum width threshold for these tools was an important consideration in the decision to discard, as narrower specimens might have been more prone to breakage from stresses applied during use. The variation in widths, however, suggests that these tools may instead have been abandoned at

various stages in their use-lives.

Humpback Scrapers

Humpback Scrapers may represent a particular sub-type of End Scraper, as their morphology is quite similar in some ways to that of the other End Scraper specimens. However, there were so few Humpback Scrapers recovered (n=4 Early period; n=1 Mid period) that any assessment of their relationship to the other End Scrapers is difficult. The specimens recovered from the Early levels were all complete or relatively complete, while the single Mid period specimen is missing its proximal end. While their outline morphology is quite similar to that of the End Scrapers, with distinctive modifications to the distal end and a narrower proximal end, their longitudinal sections differ dramatically, having a characteristic thickening (“hump”) toward the distal end of the tool. Maintenance of this outline morphology likely would result in changes similar to those expected for the End Scrapers, assuming that the distal end represents the working edge of the tool. Specifically, I would expect tool length to become reduced and for changes to occur in bit morphology over successive resharpening episodes.

An examination of the relationship between overall tool size (measured as a ratio of length to width) was difficult to assess for the humpback scrapers, given the small size of the sample. Little patterning was noted in the data, and statistical assessment was impossible given the small sample.

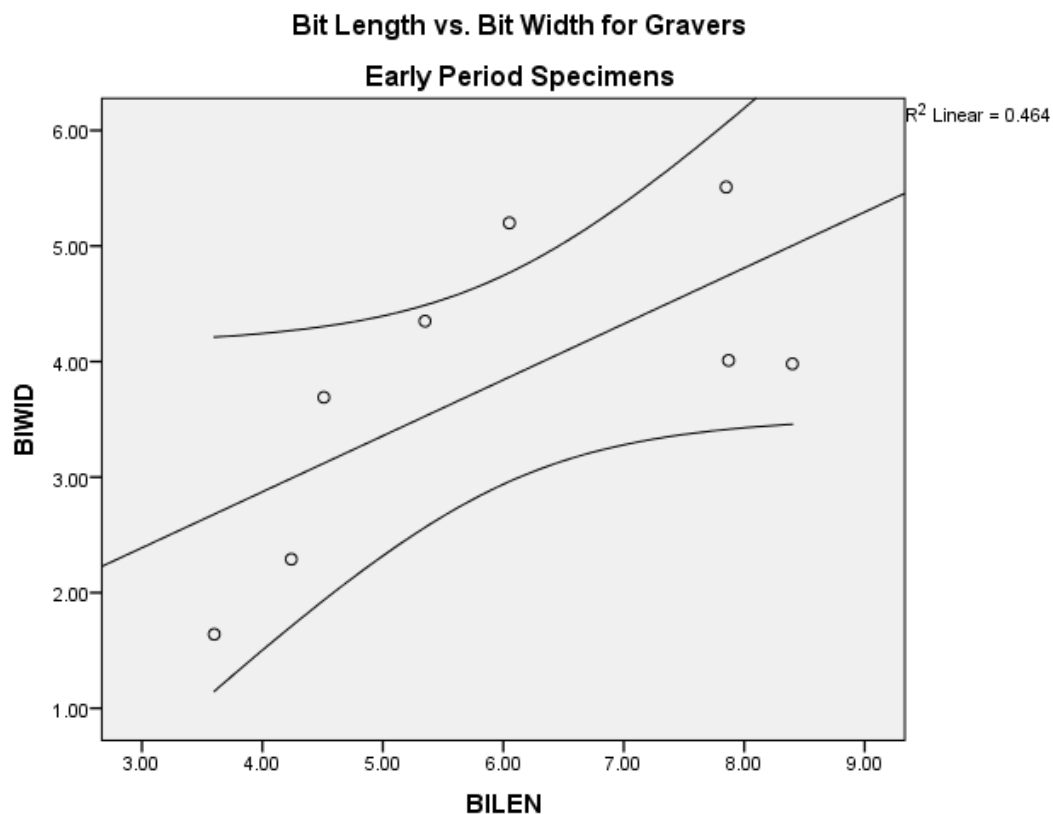
Other Unifaces: Gravers

Gravers are found in greatest frequency in the Early period sample. These tools, which likely functioned as implements for incising or engraving hard materials such as bone, antler, or

wood, are apt to have experienced significant wear as a result of being used to work dense materials. Incising these hard materials would have worn down the graver bits, especially along the length, requiring resharpening through successive episodes of use. It is proposed that bit length would have changed more dramatically than would either bit width or bit thickness.

Specimens of different lengths were noted, and it appears that longer bits tended to be wider while shorter bits tended to be narrower, although the pattern is not significant at the 5% significance level ($R^2 = 0.464$, $p = 0.063$; Figure 7.23). This pattern may be related to requirements for use and for ease of manufacture. Longer bits may have been easier to produce if they were also broader, and these broader, longer bits may have been less susceptible to breaking under the forces applied during use. The spread of thickness measurements is fairly restricted (approximately 2.0-3.5 mm), compared to the greater spread of length measurements (approximately 3.5-8.5 mm) and width measurements (approximately 1.5-5.0 mm). An examination of bit thicknesses seems to indicate that there is an appropriate range of thicknesses for these tools (Figure 7.24). Specimens that are too thin would have been prone to breakage during use, while specimens that are too thick may have produced grooves that were too wide.

There also appears to be a moderate relationship between bit width and bit thickness. This relationship is positive, but is not significant ($R^2 = 0.252$, $p = 0.204$; Figure 7.25). Bits that are wider also tend to be thicker. Once again, though, the range of thicknesses is much more restricted than the range of widths, suggesting that thickness may have been a greater factor in production design and/or the decision to discard.

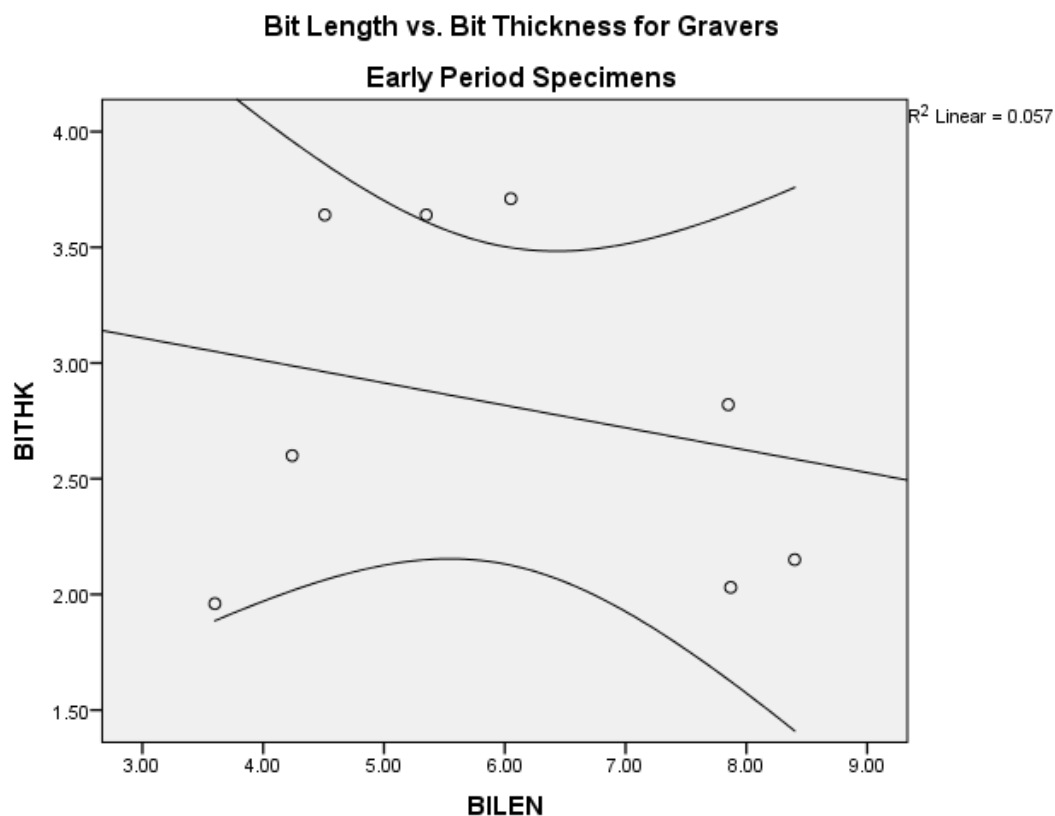


ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.230	1	11.230	5.203	.063 ^b
	Residual	12.950	6	2.158		
	Total	24.180	7			

a. Dependent Variable: BILEN

b. Predictors: (Constant), BIWID

Figure 7.23: Scatterplot for Early Period Graver Bit Length vs. Bit Width. (Primary measurement data available in Appendix A, Table A-2.)



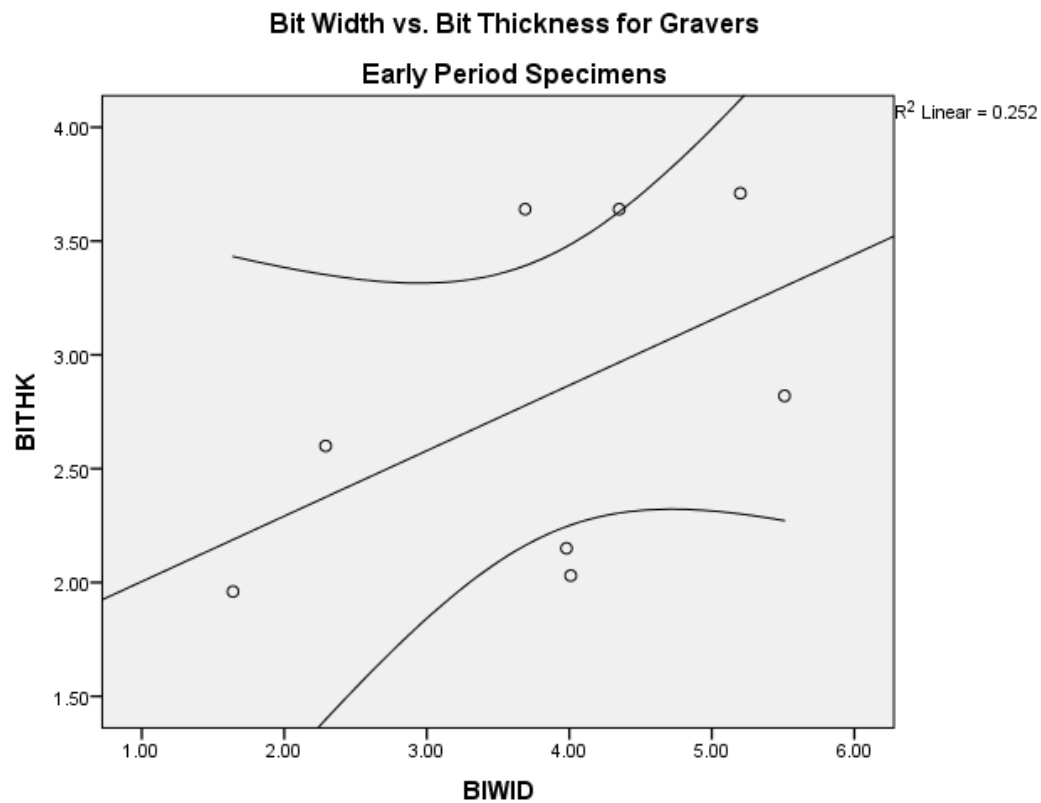
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.375	1	1.375	.362	.570 ^b
	Residual	22.805	6	3.801		
	Total	24.180	7			

a. Dependent Variable: BILEN

b. Predictors: (Constant), BITHK

Figure 7.24: Scatterplot for Early Period Graver Bit Length vs. Bit Thickness. (Primary measurement data available in Appendix A, Table A-2.)



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.082	1	3.082	2.026	.204 ^b
	Residual	9.129	6	1.522		
	Total	12.212	7			

a. Dependent Variable: BIWID

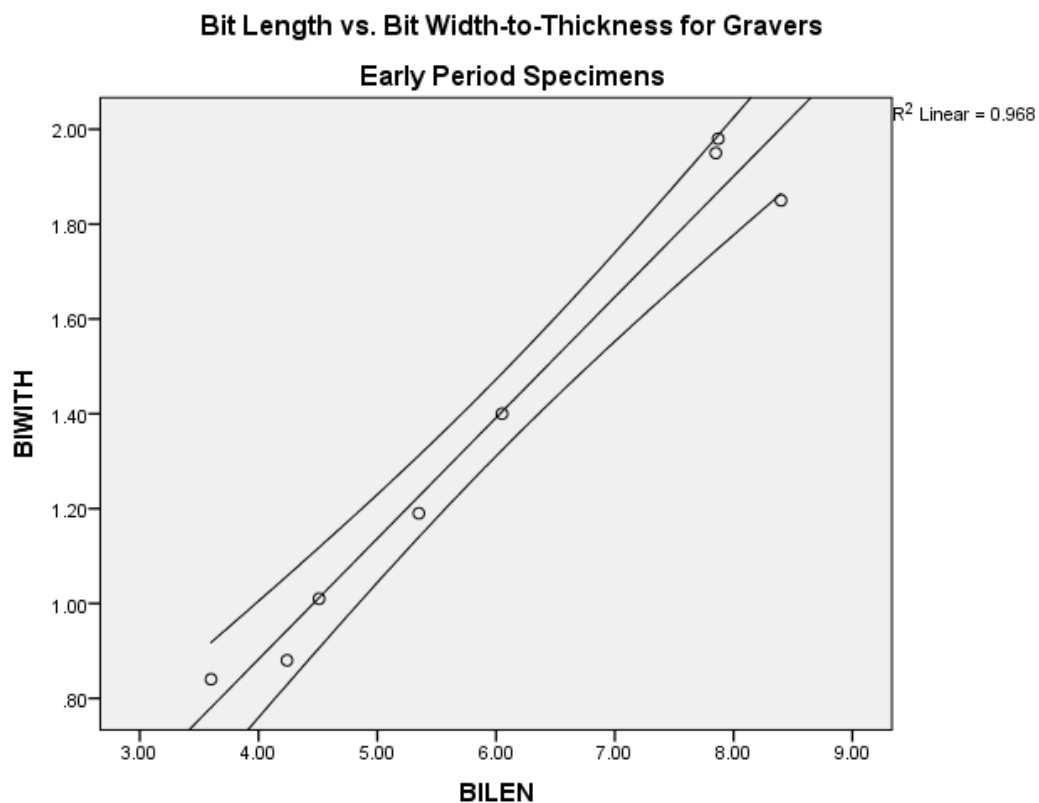
b. Predictors: (Constant), BITHK

Figure 7.25: Scatterplot for Early Period Graver Bit Width vs. Bit Thickness. (Primary measurement data available in Appendix A, Table A-2.)

Plotting bit length against bit dimensions (measured as the ratio of width-to-thickness), we see a positive relationship, but one that does not appear statistically significant ($R^2 = 0.057$, $p = 0.570$; Figure 7.26). Bits that are longer also tend to be wider compared to thickness. This relationship suggests to me that the differences in bit width and length dimensions may be a function of bit wear and bit resharpening, which would have removed length and width of the tool but would have left thickness intact. A minimum thickness threshold likely was identified by toolmakers who knew how much force a piece of a given thickness could withstand during use. At the same time, a maximum thickness threshold likely was identified for the production of appropriate-sized grooves.

General Unifaces

Little can be said regarding degree of exhaustion and stage of use life among the general unifaces, as most specimens are fragmentary. Two of the sub-classes of general Unifaces are categorized according to the number of modified edges (TI and TII), but it is impossible to say whether these sub-classes represent actual morphological or functional types, based solely on the number of modified edges present. Because most of these tools are fragmentary, little can be said of tool morphology or other potentially illuminating characteristics, such as the nature of proximal modifications, edge morphology, etc. The third category (TIII), which likely represents fragments of dorsally flaked End Scrapers, cannot be assessed to any degree because all pieces are proximal fragments. Assessment of the degrees of exhaustion among the End Scrapers was based primarily on changes that occurred during resharpening of the used distal tool end. Proximal ends would have remained essentially unchanged through use, with the exception of unintentional modification that results from damage during use (e.g., crushing or abrasion in the



ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.397	1	23.397	179.393	.000 ^b
	Residual	.783	6	.130		
	Total	24.180	7			

a. Dependent Variable: BILEN

b. Predictors: (Constant), BIWITH

Figure 7.26: Scatterplot for Early Period Graver Bit Length vs. Bit Width-to-Thickness. (Primary measurement data available in Appendix A, Table A-2.)

haft, smoothing during hand-held use). As such, these proximal portions provide no means of assessing degree of use beyond simply examining the extent of this unintentional damage. It is difficult, though, to quantify degree of use or exhaustion from such traces. The presence of proximal fragments could indicate of breakage during manufacture or the disposal of tool fragments, broken off-site and returned to Dust Cave in their hafts for retooling. The fourth sub-category is simply a catch-all category that encompasses a variety of fragmentary specimens that could not be classified reliably into any other category. It is impossible to discern what “types” are actually represented and, therefore, impossible to conclude anything about their degrees of use/exhaustion.

The category of Perforators (also called “unifacial drills”) contains so few specimens that no patterning could be discerned among the tools recovered from any given zone. The only certain conclusion is that these implements were being discarded when they were broken. The question remains, though, of when tools were damaged: during manufacture, use, or retooling?

Minimally Modified Flake Tools

The categories of minimally modified flake tools, which include Intentionally and Unintentionally Modified Flakes, should not exhibit any traces of reuse and resharpening.

Intentionally Modified Flakes (sometimes called Retouched Flakes) are modified along portions of their margins in order to alter edge morphology or edge angle slightly. However, there is no evidence on these artifacts for repeated episodes of use and resharpening.

Examination of the specimens showed no consistency in the selection of particular edges for modification, making it difficult to predict the sorts of changes that we might expect to see if they underwent multiple episodes of use or resharpening. All working edges were located on

different parts of the flakes and exhibited different morphological characteristics. It is likely, given the variety of working edge locations and morphologies, that these implements were being used for diverse purposes. Changes in tool size (e.g., an examination of length-to-width ratios) might be considered as an indicator of use and resharpening, although the variety of edge morphologies and locations, and the presumed variety of uses to which these tools were put, makes predicting the sorts of changes that would occur through use and resharpening difficult, if not impossible. It is true that these implements were being modified during production, with edges being altered slightly from their natural characteristics upon removal from the core, but it does not appear that they were being resharpened. There is no reason, therefore, to expect any changes in edge angle.

Unintentionally Modified Flakes (“utilized flakes”) are classified on the basis of their exhibiting evidence for use, but no evidence for intentional flaking of the working edge. Because these implements were not being modified intentionally, there is no way to anticipate the sorts of wear patterns that might be expected throughout use. While edge morphology might change in some way, as the tool became damaged during use, it is impossible to predict the precise nature of these changes, given the variety of uses to which these tools likely were put. No changes would be visible in working edge angle, either, as the edge angle was not altered from its initial character upon removal from the core. The only flakes that were removed from these tools are those that were removed incidentally through damage during use. Similarly, there is no way to predict changes that might occur in edge morphology, as flake edge morphology was not standardized initially. Flakes with already appropriate edges appear to have been selected and put to use in a variety of tasks. We might not even expect to see any dramatic or particular changes

in artifact size, as these implements were used only briefly and, therefore, may not have become worn down.

SUMMARY AND DISCUSSION: TECHNOLOGICAL CHANGES

From the above discussion of technological patterns at Dust Cave, changes and consistency through time in the technological assemblage may be summarized.

Early (Paleoindian – Zones T, U)

When the Early zones as a whole are considered, as opposed to the specific Paleoindian zones (T, U), we see that these earliest deposits produced the lowest artifact counts. Despite the comparatively low number of artifacts in the Paleoindian deposits, these levels revealed the greatest artifact diversity. The large number of artifact classes recovered may represent either a wide range of activities being carried out at the site or toolkits being geared-up for a variety of activities that were carried out off-site during the remainder of the settlement-subsistence cycle.

Early and Mid Stage Bifaces were quite uncommon in the early period deposits, while Trimmed Bifaces were significantly more common. Despite the relatively large numbers of Trimmed Biface I and Trimmed Biface II specimens recovered, their frequency does not match the larger numbers excavated in other zones. Hafted Bifaces and Probable Hafted Bifaces (HAB, PHB) were equally infrequent in the Paleoindian deposits, compared to later general zones, especially the Early Side Notched. Drills are present, but in very low numbers in the Paleoindian deposits, a pattern that persists throughout occupation deposits at the site. Many specimens that could be classified only as general Unifaces were recovered from the Paleoindian deposits, and represent the highest frequency from any zone at Dust Cave. The number of Intentionally

Modified Flakes (RFL) was highest in the Paleoindian deposits, which runs contrary to expectations that these tools became more common in later assemblages. As discussed later, though, they become more common in later deposits *in relation to other tool classes*, perhaps replacing the functions of many of the specialized uniface types, which fell out of favor as the frequency of bifacial tools began to increase. In contrast to the great frequency of Intentionally Modified Flake implements, the Unintentionally Modified Flake (UFL) tools were recovered in relatively low frequency compared to the numbers in which they were recovered from many of the later period deposits. It is possible that the line between formal unifaces and Intentionally Modified Flake tools was an ill-defined one, and that the Intentionally Modified Flakes might be better categorized, from a functional standpoint, with the other unifaces. If this were the case, then the low frequency of Unintentionally Modified Flake tools may fulfill the expectations that these implements were less common in the earlier periods when more formal unifacial tools were used, and became more important in the technological assemblages of the later occupations.

A variety of specialized flake tools were also recovered, including various scraper types, graters, and blade implements. These types are not ubiquitous, appearing only in particular zones, generally from the earlier periods. End Scrapers, which are a commonly recovered artifact type on early sites across North America (Deller and Ellis 1988; Ellis and Deller 1988; Frison 1991; Irwin and Wormington 1970; Judge 1973; Morrow 1997; Wilmsen and Roberts 1978), were recovered from the Late Paleoindian deposits in lower frequencies than might have been expected. In fact, their frequency is lower in the Late Paleoindian period assemblage than it is in the Early Archaic. While their numbers were low in the Paleoindian deposits, they still were recovered with greater frequency from these Early levels than they were from either of the Middle Archaic “Late” period zones. Part of the reason for their infrequency may be the

ephemeral nature of the Late Paleoindian occupation or the scouring of early deposits, as noted by Homsey (2004). The numbers of End Scrapers is increased when Type 3 Unifaces are included in the sample. These specimens likely represent proximal fragments of dorsally flaked End Scrapers. The results of functional analysis, discussed in the following chapter, indicate that these implements were used in hide scraping. Their presence at Dust Cave suggests that hide scraping certainly was carried out by the inhabitants of Dust Cave, but we must consider further patterning in the data to determine whether these implements were being used on-site, or simply were being discarded on-site. This possibility is considered further, below.

Other scraper types were also recovered. Side Scrapers were restricted primarily to the Paleoindian deposits but were not recovered in large numbers. Similarly, most of the Ovoid Scrapers were recovered from the Paleoindian zones. Humpback Scrapers were represented in very low numbers in the Paleoindian period. Their representation remains minimal in later deposits as well. Several scrapers produced on blade-flakes were also excavated from the Paleoindian levels and reinforce the importance of blade technology at this time.

In addition to these various Scraper types, a small number of Gravers were recovered. Representation of these tools on the site was minimal, but the majority of specimens recovered were assignable to the Early period Paleoindian zones. While their functions are discussed in greater detail in the following chapter, it appears that these implements were used to engrave hard substances such as bone, wood, or antler. It is likely that they played a role in the production of technology, such as the manufacture of shafts, foreshafts, or hafts for implements such as Hafted Bifaces or Scrapers.

Other minimally modified blade implements (Intentionally and Unintentionally Modified Blades) were recovered from the site, reinforcing the importance of the specialized blade

technology during the Late Paleoindian period. Great effort was expended in the production of the cores from which these specialized blanks were removed, and so use of the products in such an expedient manner might seem to be an imprudent expenditure of that effort. It is possible, though, that these flakes may have been deemed unsuitable for transformation into other tools or for transport and further modification throughout the settlement-subsistence cycle. They may also represent extra blanks that were transported but not used during the time away from Dust Cave, and therefore were used expediently, upon return to the site, while inhabitants re-gearred their toolkits.

While the Late Paleoindian deposits revealed a collection of tool classes that were ubiquitous through time at Dust Cave, the Paleoindian period toolkits may truly be characterized by the prevalence of specialized unifacial implements (various Scrapers, Gravers, other Unifaces), many intentionally modified flake tools, and specialized blade tools (Blade Scrapers, Intentionally and Unintentionally Modified Blades).

Raw material selection in the Paleoindian zones was restricted almost exclusively to variants of Fort Payne chert, especially of the Blue-Grey variety. Few non-local raw materials were noted in the assemblage, which might suggest restricted mobility but more likely represents a focus on this high-quality and easily accessible stone source.

A consideration of core and blank production revealed that blade flakes were of great importance in the Paleoindian technology. Other blank types were identified, but these tended to be recovered in much lower frequencies. While this pattern may be a function of the comparative ease of identifying blades over other blank types, the common appearance of blades on other Paleoindian sites in North America suggests that the pattern at Dust Cave likely is a real one.

The production of standardized cores for the removal of predictable blanks may have contributed to some of the high degrees of standardization noted in the attributes of certain tool classes in the Paleoindian deposits. However, standardized measurements are not restricted to those implements made on blades, and certain tool classes even exhibit a lack of concern with consistency in attributes.

Because of the low numbers of Early Stage Bifaces and Drills recovered, no assessment of standardization was possible for these classes. While few Mid Stage Bifaces were recovered, moderate standardization was noted in all of the basic dimensions (length, width, thickness). This may indicate modification of these tools into preforms that were destined to become more refined Trimmed Bifaces. The Trimmed Biface I specimens exhibited moderate to low levels of standardization in all basic dimensions, while the Trimmed Biface II specimens were quite variable. Perhaps, among these tools, many of which may have been destined to become Hafted Bifaces, the length, width, and thickness measurements were of lesser concern than were the proximal (i.e., haft) measurements.

Among some of the classes of specialized unifaces we see the greatest degrees of standardization in the Paleoindian chipped stone assemblage. In both the complete dorsal (CD) and marginally flaked (MF) End Scraper (ESCR) categories, high and very high levels of standardization in bit angle were noted. Width, bit width, and proximal thickness were also highly standardized in both of these categories. Moderate levels of standardization in thickness and bit thickness were recorded among the complete dorsally flaked specimens and relatively low standardization in the same attributes of the marginally flaked specimens.

The Blade End Scrapers (BESCR), produced on standardized blades and modified only marginally, exhibited high levels of standardization in bit angle, width, and bit width. The

consistency in width and bit width are likely related to the use of standardized blanks that may have been produced with consistent dimensions already in place. While bit angle consistency may be related to functional requirements, other researchers have suggested that bit sharpness rather than bit angle may have been more important to the functioning of these tools (Comstock 2011; Seeman et al. 2013). If the latter suggestion is correct, then the consistency in bit angle may represent of unintentional bit angle changes and the timing of discard rather than a concern with this attribute during tool maintenance. Thickness was also highly standardized among the Blade End Scrapers, with levels even higher than were seen among the complete dorsally flaked specimens.

Less standardization was noted among the other varieties of scrapers, including the Side Scrapers produced on blades. An exception is the moderate or high levels of standardization in the sample of Ovoid Scrapers, which may be a function of the small sample size. None of the Ovoid Scrapers appeared to exhibit evidence for hafting, meaning that standardization likely would have been of little concern among these tools with the possible exception of maintaining an edge angle appropriate to carrying out particular tasks. Bit angle was highly standardized in the small sample of Humpback Scrapers (HSCR), and length was highly standardized, but all other attributes were quite variable. It is unclear, from technological examination alone, whether these tools actually represent a single functional class, an issue that will be considered in the following chapter.

No standardization was noted among the general Uniface sub-classes, which is not surprising, given the presumably mixed nature of these categories. In addition, nearly all of the specimens identified only as “Unifaces” were fragmentary, making assessment of standardization in any attributes difficult. A lack of standardization was noted in the minimally

modified flake and blade tools as well (Intentionally and Unintentionally Modified Flakes and Blades), reflecting the unmodified nature of these specimens.

The majority of specimens from all classes in the Early period were fragmentary (64% in specific zones, 67% in general sample), but the proportion of fragments in the Paleoindian sample is lower than that seen in the Early and Middle Archaic periods.

Breakage patterns in several of the tool classes (Stage Bifaces, Trimmed Bifaces, and Drills) are suggestive of errors during manufacture, as they exhibited no evidence for use and were represented by both proximal and distal portions. While some Drills were hafted, and may have been returned as proximal fragments that were still embedded in their hafts, it is unlikely that toolmakers would have transported distal fragments to Dust Cave, had they been used off-site. The presence of proximal and distal portions therefore suggests use of these implements on-site. As these tools functioned in drilling substances such as bone, antler, and wood (see Chapter 8), it is likely that they were employed in the manufacture of organic tool components on site.

Similarly, End Scrapers were represented by proximal and distal fragments, as well as by complete and relatively complete specimens. This pattern suggests use of at least some of these tools on-site. The complete/relatively complete artifacts could represent items that were used on-site or items discarded during the course of retooling exhausted specimens that had been used off-site. Among the fragmentary End Scraper specimens both proximal and distal fragments were recovered, which may indicate breakage during use on-site or discard of broken implements during retooling. It has been suggested that toolkit replenishment, with discard of implements that had become reduced sufficiently to diminish the maximum potential number of resharpening episodes, is the most likely explanation for the End Scraper discard patterns. Most specimens within the other scraper categories were complete or relatively complete, suggesting use of these

implements on-site or retooling of exhausted but complete items. It is likely that these implements were being discarded during the course of toolkit replenishment, following intensive periods of use. This possibility will be considered in greater detail in the concluding chapter, with additional support drawn from the results of my functional analysis.

According to their morphological characteristics, the other scrapers were not hafted, but significant investment in post-detachment modification of certain sub-classes (e.g., Ovoid Scrapers, Humpback Scrapers) suggests anticipation of an extended use-life, which might indicate either use throughout the settlement-subsistence cycle, or intensive periods of use on-site. Some specimens (e.g., Side Scrapers) were minimally flaked, which may indicate a lesser concern with elements of curation, particularly transport and successive episodes of use and resharpening. Many of these minimally modified Side Scrapers were produced on blade blanks, meaning that effort was invested at an earlier stage in the production sequence, specifically during core preparation, rather than during blank modification. A consideration of degrees of exhaustion may provide insight into the role played by these minimally modified but formal implements.

The other general Unifaces were more often fragmentary, being represented especially by proximal fragments. This pattern is a function of their classification, as the distal ends of unifaces tend to have been modified into bits with specific functional purposes. These distal fragments would have been easier to identify and classify into a particular class based on their more distinctive morphology and assumed function. Proximal fragments, on the other hand, would have been less easily identified, either being unmodified from the stage of blank production or having received modifications for hafting that often were indistinguishable across classes. The prevalence of proximal fragments in the Uniface category therefore speaks to my

inability to classify these tools beyond being able to say that they were modified unifacially along n number of edges. A lack of standardization of the proximal ends may suggest either a lack of hafting modifications or a mixture of types within single categories. The prevalence of proximal fragments might also suggest that hafted artifact assemblages were being retooled at the site, except that few of these proximal fragments exhibited distinctive hafting modifications.

Among the Intentionally and Unintentionally Modified Flake specimens, more fragments were noted than complete or relatively complete specimens. It is often difficult to discern, however, whether these implements were broken after being used or if they were manufactured from flake fragments, unless we see flaking or microflaking across the broken facet.

Examination of the Intentionally and Unintentionally Modified Blades (RBLD, UBLD) revealed fairly even representation of complete/relatively complete and fragmentary specimens. Fragments included fairly even representation of proximal, medial, and distal portions. Their lack of evidence for repeated episodes of use, in association with the lack of evidence for patterning in fragment representation, confirms their function as expedient implements and suggests to me that they may have represented blanks that were deemed unsuitable for modification into other tool types or transport away from the site of manufacture.

Because of a lack of evidence for use of the Stage Bifaces (ESB, MSB) and Trimmed Bifaces (TBI, TBII), and because the stage biface categories were represented by so few specimens in the Early deposits, no consideration could be given to the question of use-life or extraction of utility for these categories. While this issue was not addressed for the Hafted and Probable Hafted Biface categories, the amount of effort invested in their production suggests the expectation of an extended use life. This means either that toolmakers anticipated either using

and resharpening the tools during intensive periods of use or using the tools for extended periods over the course of the settlement-subsistence cycle.

Few Drills were recovered, making it difficult to draw any definitive conclusions regarding their use lives. Within this class, the width-to-thickness ratio was the only measure of utility extraction that was deemed valuable. The category is replete with fragmentary specimens, making any assessment of use-related changes difficult or impossible. Consistency in both means and ranges of width-to-thickness values suggests a minimum threshold (approximately 1.5) beyond which these tools may no longer have been deemed usable. Given the small numbers of tools and the fragmentary nature of the sample, it is difficult to say much, but if we consider their presumed uses (e.g., tool manufacture), it is likely that the drills were used on-site rather than being transported over great distances. While the majority of these specimens exhibited evidence for hafting, it is likely that these modifications were applied to facilitate prehension and to allow appropriate amounts of force/pressure to be applied to these tools while simultaneously reducing hand stress.

In the discussion of standardization in the End Scraper category, a high degree of standardization in bit angle was noted. The narrow range of means for this variable suggests that changes in bit angle may have been largely responsible for the decision to discard implements within this tool class, at least among the complete dorsally flaked specimens. Too few marginally flaked specimens were available for examination, making it impossible to draw any strong conclusions regarding their use lives. Among the marginally flaked End Scrapers we do see a broader spread of bit angles and a narrower, although still fairly great, range of bit convexities. Length does not appear to have been a concern when discarding these implements. It is likely that, as long as bit angle could be maintained, tools were regarded as retaining utility. Bit angle

likely was easier to maintain than bit convexity, as convexity changes rapidly once the bit approaches the juncture with the haft. Bit angle, on the other hand, could continue to be maintained at the most convex middle portion of the bit, even once the bit began to straighten.

Bit angle, or working edge angle, seems to have been of less concern in the decision to discard specimens of other scraper categories. Among the Side Scrapers, changes in width appear to have dictated the timing of discard. Those tools that became too narrow relative to their thicknesses were abandoned, with final width-to-thickness ratios exhibiting a very narrow range of values. The range of edge angle values, on the other hand, was much greater, suggesting less concern with changes in this dimension. Despite the wide spread of angles, there was a general association of steeper angles with narrower specimens and more acute angles with wider specimens. This pattern suggests that tools became narrower and steeper-edged through successive episodes of resharpening. The potential of the implement to fail, from a structural standpoint (i.e., breaking because it was too narrow), seems to have been the greatest concern in the use and discard of the Side Scrapers.

The Ovoid Scrapers appear to have been discarded at various stages in use-lives, as indicated by a wide range of edge angles and a range of linear dimensions. We see long-wide specimens with acute edge angles, as well as short-narrow specimens with steeper edge angles. While the relationship between these variables (angle vs. the width-to-thickness ratio) is a moderately strong one, the spread in all of these dimensions is too great to suggest which marker might have been the key factor in the decision to discard. The lack of consistency in or a notable limit to any attribute that might suggest discard when certain pressures became too great (e.g., potential for the tool to fail, or potential for task failure) and may suggest that these tools were being used somewhat expediently on-site, rather than being curated (i.e., transported,

resharpened, and re-used repeatedly at sites removed from Dust Cave). Discard may simply have occurred whenever tool users completed the tasks in which the Ovoid Scrapers were utilized. Certain specimens, though, exhibited great investment in production, although they were not hafted. This pattern may indicate their use in brief but intensive periods of activity on-site. Functional analysis has suggested their use in more generalized activities (see results, Chapter 8), suggesting that these tools may have been general-purpose implements used at Dust Cave for a variety of domestic purposes. They may simply have been left at the site once the nomadic population left to pursue other resources throughout the year. Other tools and blanks, notably the large, easily-modified blades, may have been favored for transport because of the ease with which they could be transformed into a variety of implements to serve both anticipated and unforeseen needs.

Very little can be said about the discard of Humpback Scrapers, simply because the sample size is so small, but the narrow range of bit angles represented suggests that changes in this attribute may have been a significant factor in the decision to discard. This pattern matches that noted among the End Scrapers, discussed above. It is possible that the Humpback Scrapers simply represent a subset of End Scrapers.

Among the Blade End Scrapers, a very narrow spread of bit angles upon discard ($>10^\circ$) was noted, reflecting either the importance of this attribute in the decision to discard, or the unintentional bit changes that occur during resharpening. This same pattern was recorded among the non-Blade End Scrapers and the Humpback Scrapers. While changes in bit convexity may be a better indicator of the degree of resharpening (i.e., how many resharpening episodes an implement has experienced), it seems discard may have been dictated by steepness of the bit, rather than its relative convexity. On the other hand, if the suggestion by Comstock (2011) and

Seeman et al. (2013) is correct, then the ability to maintain a sharp bit was of primary concern. The consistency in bit angle may, therefore, simply reflect a fortuitous artifact of the timing of discard, when bits could no longer be resharpened because of reduced length, which happened to coincide with an inability to create less obtuse edge angles.

Blade Side Scrapers exhibited a pattern contrary to that noted among the non-Blade Side Scrapers. Specifically, the range of working edge angles was quite narrow, while the range of width-to-thickness ratios was much wider. I suggested, for the other Side Scrapers, that width of the specimens, specifically relative to their thickness, may have been instrumental in determining when to discard the implement and that edge angle seemed to be less important. The opposite seems true among the Blade Side Scrapers. It is important to note, however, that the sample size was very small and any patterns detected may therefore be more apparent than real. Regardless of this change in patterning, an association of wide specimens with acute angles, and narrow specimens with steeper angles continued to be noted.

The General Uniface (UNF) category was populated almost entirely with fragmentary specimens, making an assessment of use-life and the decision to discard difficult. While bit fragments were available for study, many were too fragmentary to allow the types of relational measures used in assessing relative changes in attributes through reduction and reuse. It is obvious that these tools were discarded when broken but unclear whether they were broken during manufacture, use on-site, or as part of retooling efforts upon returning to Dust Cave. The fact that this category also includes specimens of potentially a wide variety of classes, categorized only on the basis of the number of edge margins that were modified on any given fragment, makes assessments impossible.

Among the Intentionally and Unintentionally Modified Flakes and Blades, it was impossible to predict the sorts of changes that might occur throughout the use history of these tools because of an utter lack of consistency in form. These tools were produced from a variety of flake types, with a variety of edge morphologies. There is no evidence for successive episodes of use and resharpening among the Intentionally Modified specimens, and Unintentionally Modified specimens were not even modified purposefully. Immediate use and discard is, therefore, assumed. These tools likely served to fulfill an immediate need, one that may or may not have been anticipated. Because of the ease of access to raw materials at the site, use of expedient flake tools while on-site would have been a reasonable strategy, as these tools could have served a multitude of generalized functions, similar to those performed by more specialized implements and by generalized but more formal implements (e.g., the Side Scrapers and Ovoid Scrapers, unhafted Bifaces, etc.), without requiring the investment of time or energy in the production of tools for those immediate purposes. Toolmakers may have saved those more formal implements, which required a greater investment in their production, for use while away from the site where technological materials were less easily accessible, where needs may have been unpredictable, and where time pressures in task performance would have been more pronounced, and more risky.

From the discussions above, some general conclusions can be drawn about the nature of the Paleoindian levels and the Paleoindian toolkits. It is clear that tools were being produced on-site at this time. Some implements, such as the Intentionally and Unintentionally Modified Flakes, were being used on-site, while others, such as the formal Hafted Bifaces and certain blade tools, were being produced for use off-site. At least some of the End Scrapers may have been used during periods of occupation at the site, while others may have been produced for

transport and use elsewhere. Side Scrapers also appear to have been discarded during retooling activities at Dust Cave. Tools appear to have been discarded prior to their potential for failure during use in activities while away from the site. The Side Scrapers appear to have been multi-purpose tools, and might better be thought of as unifacial knives than as scrapers. Their function(s) will be elucidated in the following chapter in my discussion of use-wear traces. The Ovoid Scrapers appear to have been used on-site, and were discarded at various times. They may have fulfilled functional needs during more intensive periods of processing. Walker (1998) has suggested that the hunting of migratory waterfowl appears to have been an important activity during the Paleoindian occupation, and it is possible that these tools served as butchering implements, as the use-wear analysis (discussed in the following chapter) suggests their use as cutting rather than scraping tools.

Mid (Early Archaic – Zones P, Q, R)

The number of artifacts recovered from the Middle Period deposits increases compared to the Early Period but still lags far behind the frequency of artifacts in the general Late Period deposits.

Artifact diversity remained relatively high in the Mid Period, especially in the Early Side Notched deposits. The number of artifact types represented drops slightly by the Kirk Stemmed period, but is still higher than the numbers seen in the Late Period zones. Unlike in the Paleoindian deposits, there is no evidence for exclusive or near-exclusive representation of any particular tool class by the Early Archaic period. Hafted Bifaces are the most commonly recovered artifact class in the Early Side Notched deposits, with Unintentionally Modified Flakes a close second. The number of Hafted Bifaces recovered from the Mid Period deposits represents

a large increase over their recovery in the Early Period levels. In the Kirk Stemmed period, Unintentionally Modified flakes were most common, followed closely by Hafted Bifaces. These patterns are even more pronounced when considering the general Mid Period deposits, rather than the specific Mid Period zones. The frequency of flake tool types, notably various Scraper categories and general Unifaces, drops dramatically when compared to their great frequency in the Paleoindian deposits. Ovoid Scrapers, Intentionally Modified Blades, and Unintentionally Modified Blades were not recovered from these deposits, and Gravers had become very rare. These observations suggest an increased emphasis on biface tools at the time in relation to the formal flake tools that were so common in the Early Period deposits. This change may suggest a shift in the functional role of these tool classes, a point that is considered in greater detail in the following chapter.

As was the case with the Paleoindian period sample, most of the tools from the Early Archaic Mid Period zones were produced from variants of Fort Payne chert, especially the Blue-Grey type. There was little reliance on any sources that we might consider “exotic” or non-local.

An examination of evidence for core production and blank selection revealed a decrease in the production and use of blades, and an increase in the use of biface-derived flakes, which correlates with the greater apparent emphasis on the use of bifaces as tools at this time. No dramatic changes were noted in the representation of any other blank or core types.

This shift away from the focus on standardized blank production could have contributed to lesser degrees of standardization in tool dimensions at this time or may have forced the production of standardized attributes through the application of more substantial post-detachment modification. Moderate to very high levels of standardization were noted in all dimensions of the Mid Stage Biface specimens, suggesting that these implements may have been progressing

toward becoming preforms for more formalized bifaces (e.g., Trimmed Bifaces or Hafted Bifaces). On the other hand, this degree of standardization might simply be a function of small sample size. Trimmed Bifaces (TBI and TBII) exhibited relatively low levels of standardization. If these tools were destined for modification into preforms for Hafted Bifaces, then it is possible that the effort of the toolmakers shifted toward producing standardized proximal dimensions for hafting rather than consistency in other dimensions.

The End Scrapers were produced from a variety of blank types at this time, with a reduction noted in the reliance on blades compared to the Late Paleoindian sample. So few specimens were recovered as to make any consideration of the differences between the complete dorsally flaked and marginally flaked specimens impossible. Relatively high degrees of standardization were noted in many of the measurements of both the complete dorsal and marginally flaked End Scrapers. Bit Angle, Proximal Thickness, and Bit Width exhibited the highest degrees of standardization. Standardization in the Bit Angle may be related to the functional requirements of hide scraping, which may impose upper and lower limits on acceptable bit angle. The standardization of Proximal Thickness may indicate the use of socket hafts, which is suggested for the Early Period specimens as well. Nothing could be said about the other scraper categories simply because sample sizes were too small. Only two Ovoid Scrapers and a single Humpback Scraper were recovered. No Blade Scrapers (End or Side) were recovered from the Mid Zones, reflecting the shift away from the importance of blade technology at this time. It is, therefore, difficult to say much about changes in scraper standardization from the Early to the Mid period, simply because so few specimens were available for comparison. The only pattern that is apparent across periods is that the same dimensions appear to have been emphasized in End Scraper specimens. What *is* significant,

though, is the dramatic decrease in the representation of this tool class from the Late Paleoindian period to the Early Archaic. This shift reflects either a change in needs, or a change in the way that the same needs were being met in these two periods. The analysis of tool function, in the following chapter, will provide additional insight into this issue.

Only one Graver and one Perforator were recovered from the Mid Period levels, so no analysis of standardization could be conducted. It is perhaps significant, though, that the graver class, especially, was disappearing, perhaps indicating shifting functional needs or changes in how or where these needs were being met. In other words, the production of tool components that required gravers may have been occurring elsewhere, or those tool components that were being produced with gravers may have become less common, being replaced by other technological elements. As was the case with the Early Period General Unifaces, almost all specimens in this class in the Mid Period levels are fragmentary, and the “type” divisions may represent a mixture of morpho-functional classes, as they are categorized only based on the number of utilized edges. Because of these issues, assessing standardization is impossible. That being said, the Type 3 category (tapered, dorsally flaked proximal uniface fragments) represents fragments of what have been interpreted as proximal portions of complete dorsally flaked End Scrapers. This classification is based on their technological and morphological similarities to the intact specimens. When measurable, these specimens exhibited high degrees of standardization in thickness and proximal width, matching the patterns seen in the complete specimens.

The Intentionally Modified Flakes and Blades were not altered in any consistent manner, and the non-blade specimens were produced on a variety of blank types, making attributes highly variable. Similarly, the Unintentionally Modified Flakes and Blades, which received no intentional modification at all, were also highly variable. Degrees of standardization in

dimensions were low, in some cases so low as to be considered unstandardized or to represent the intentional production of differences. This lack of standardization provides support for the assumption that these implements were produced and used expediently.

Compared to the Early Period sample, an even greater proportion of the Mid Period specimens were fragmentary. Bifaces were more often recovered as fragments than as whole artifacts. Stage Bifaces (ESB and MSB) appear to have been damaged during manufacture or during transformation into later Stage Bifaces (i.e., Trimmed Bifaces), as there was no evidence for these pieces having been used. Trimmed Bifaces also were more often fragmentary than complete or relatively complete. In the Early Side Notched (ESN) sample, many of the Trimmed Biface I fragments recovered represented proximal tool portions. In the Kirk Stemmed sample, nearly equal proportions of proximal and distal fragments were noted. Among the Trimmed Biface II specimens, distal fragments were more often recovered in both the ESN and Kirk Stemmed periods. It is likely that this apparent pattern is simply an artifact of the manufacturing process (i.e., greater modification of refined, pointed distal ends) and my classification criteria (i.e., use of the bifacial flaking index to distinguish TBI from TBII). More fragmentary than complete/relatively complete Drills were recovered, with all portions represented in the sample. The recovery of fragments from all portions of the tool suggests use of these implements on-site, as it is unlikely that broken distal fragments would have been transported back to the cave for retooling. Proximal portions certainly could have been returned to Dust Cave while still attached to their hafts, but the presence of distal fragments in the sample points to at least some Drill use on-site. It is also likely that these tools were being used in the manufacture of other tools, an activity that would have been carried out during periods of “down-time,” which would have been more available at general residential sites, rather than special activity sites. From the variety of

artifacts recovered and the variety of subsistence remains recovered, it is likely that Dust Cave was used more in a residential capacity.

While only a few Scrapers were recovered, most were complete/relatively complete. This pattern may represent use of these tools on-site or retooling of implements that were exhausted elsewhere but remained unbroken. Few General Unifaces were recovered, and the majority of these were also fragmentary.

Within the categories of Intentionally and Unintentionally Modified Flake Implements (RFL, UFL), more fragments were recovered than complete or relatively complete specimens. It is difficult to say, however, whether these tools were produced from flake fragments, or if they were broken during use or modification. Regardless, they exhibit no evidence for repeated episodes of use and resharpening, so they likely were discarded immediately following relatively brief periods of use.

Few blade tools were recovered from the Mid Period levels, and no patterning was apparent in their condition upon discard. Complete/relatively complete and fragmentary specimens were recovered.

Lack of evidence for wear on the Stage Bifaces suggests that neither the Early Stage Bifaces nor Mid Stage Bifaces were being used for carrying out any tasks, such as chopping, cutting, etc. They may have functioned as preforms for Trimmed Bifaces, or as a source of flakes for blank production. If they were “used” in such a manner, they would have been transformed to the point of no longer being classified as Early Stage Bifaces or Mid Stage Bifaces. The other alternative is that they were broken during manufacture, or were deemed unusable, and were then discarded. Early Stage Bifaces may have served as a source of flake blanks for further tool production. The Mid Stage Bifaces may have served as early “preforms” for the production of

knives or projectile tips. Specimens that remained intact through manufacturing may have proceeded to the next stage in lithic reduction: the Trimmed Biface. Those would have been identified as Trimmed Bifaces, while those that broke during reduction may have been categorized as Mid Stage Bifaces.

The presence of both proximal and distal fragments of the Trimmed Biface I and II specimens, along with a lack of evidence for use or resharpening, suggests that these tools likely were being broken during manufacture on-site. Those implements that survived the manufacturing process may have been taken from the site to be used as hand-held knives, or may have been further transformed into Hafted Bifaces. The lack of complete specimens with evidence for use and resharpening suggests either that these tools were not being returned to the site for retooling, instead being discarded off-site, or were being recycled into other tool forms after damage occurred and were discarded at the site in their new forms. Regardless, the nature of the Trimmed Biface specimens recovered from the site indicate discard early in their use-lives.

Because of the fragmentary nature of most of the bifacial Drills recovered from these levels, it was difficult to assess degree of utility extraction. My measures of use-life and utility for this class of artifact were based on relative measures (e.g., ratios of bit length to bit width or thickness). With only fragments having been recovered, though, degree of utility extraction was impossible to evaluate. Based on the recovery of fragments from all portions of the tool, I suggest that these implements likely were being used on-site. While toolmakers might have transported broken proximal fragments that were still attached to usable hafts, it is unlikely that they would have returned broken distal fragments to the site. While it is possible that toolmakers might have transported Drills off-site for use elsewhere, I am more inclined to believe that these

tools were being used on-site for the production of other classes of technology (see discussion in previous section).

Although I did not study the Hafted and Probable Hafted Bifaces in any detail, the amount of effort expended in the manufacture of these items, including effort devoted to the modification of their proximal portions for hafting, might suggest that toolmakers and users anticipated extended periods of use and reuse for these items. However, Randall (2001) noted that many of these Early Archaic tools were discarded at Dust Cave with little evidence for having undergone significant resharpening, a pattern that may reflect the proximity of a high-quality lithic raw material source. Fragmentary specimens recovered might represent those tools that were broken during manufacture or those that were returned for retooling following use off-site, or during use as projectile tips or hafted knives on-site. Complete/relatively complete specimens, on the other hand, might represent those that were identified during manufacture as being flawed or tools that were used, exhausted, and returned whole for retooling. Another possibility is that the whole specimens are those that were produced in advance of use and were cached at the site, although there is no evidence from the site to support this possibility.

Turning to the flake tools, the End Scrapers appear to have been discarded once the potential for task failure was reached rather than when the tool was completely exhausted. The narrow range of bit angles, despite the wide range of bit convexities, may suggest discard once bit angle was deemed “unusable” or may reflect of the unintentional bit angle changes and the timing of discard. In addition to variability in bit convexity, varying length measurements were noted, suggesting that these tools were discarded at various points in their resharpening/reduction sequence. Based on their lengths, many could have continued to be resharpened, but it is possible that bit angle had become steep enough that they were no longer viewed as being usable. This

suggests intensive periods of use, during which the potential for task failure was considered to be a great risk. Toolmakers may, therefore, have produced additional tools that could be substituted once a scraper became unusable rather than investing precious time during hide processing to rejuvenate a worn or broken Scraper. End Scraper specimens that were deposited at the site likely were removed from their hafts and replaced by prepared, intact specimens. In addition to fragmentary specimens, many of which may represent tools broken during use on-site, excavators also recovered complete and relatively complete examples. These whole specimens do not appear to have been used to exhaustion and instead appear to have been discarded once a particular edge angle had been reached, suggesting their discard prior to the potential for failure at critical moments. Following arguments by Comstock (2001) and Seeman et al. (2013), a second possibility to explain this discard pattern, especially given the variability in lengths, is that these tools were discarded after experiencing sufficient length reduction through rejuvenation that their maximum resharpening potential could no longer be met. Toolmakers may have opted to discard these implements and replace them with new tools that retained maximum resharpening potential in order to minimize the possibility of task failure during intensive periods of use.

Too few Side Scraper, Ovoid Scraper, Humpback Scraper, and Graver specimens were recovered to allow any assessment of patterns in utility and exhaustion. It was difficult or impossible to assess exhaustion for the category of General Unifaces because a) the four subtypes do not necessarily represent distinctive morphological or functional classes, and b) because many fragments were proximal fragments, making it impossible to examine bit characteristics for the presence of alterations attributable to use or resharpening. Some of the General Unifaces were not as formal in production or appearance as the other named uniface classes (e.g., the

various types of scrapers). It is probable that these implements were designed for periods of use on-site in tasks that were more intensive or demanding (hence, the greater formality and potential for resharpening/recycling) and that demanded specific edge morphology or other attributes. These implements appear to have been abandoned upon breakage or failure during manufacture or when the period of need had expired. It is difficult to determine whether any of these implements were being used off-site. The proximal fragments might represent items that were hafted and that were returned to the site in their still usable hafts, or they could represent pieces that were broken on-site, either during manufacture or use. Without bit portions to examine, it is impossible to determine if these fragments were discarded after significant utility had been extracted from the tools. Type 3 Unifaces were interpreted as representing broken proximal fragments of dorsally flaked End Scrapers, based on similarities in the technology and morphology between these fragments and the whole specimens that were recovered. These items likely were hafted and may have been used on-site or off-site, being returned to the site in fragmentary condition for the purpose of retooling.

None of the Intentionally or Unintentionally Modified Flake implements exhibit evidence for multiple resharpening episodes, so the degree of utility extraction from these tools can be considered minimal. They were employed for as long as they were deemed useful and discarded either when edges became dulled or when the task in which they were used was completed.

In comparing the Mid Period technological patterns to those from the Early Period, we see great consistency through time, with the exception of an increased emphasis on bifaces and a decreased emphasis on formal flake tools. While simple modified flakes continued to be used, it appears that tool users began to rely on these items more heavily in relation to their diminishing use of formal unifacial tools. End Scrapers were still highly standardized, while greater

variability was noted in many of the other tool classes, including in categories such as the Trimmed Bifaces, which were more standardized in the Early levels. Mid Stage Bifaces appear to have been the exception, exhibiting higher levels of standardization than in the Early Period. Certain classes of implements, notably the End Scrapers, appear to have been discarded at the site during the course of retooling activities. As was the case in the Early levels, the End Scrapers appear to have been discarded when the potential for task failure was high, rather than when the tools became exhausted. Many of the other tool classes appear to have been discarded after more immediate periods of use on-site.

Late A (Middle Archaic, Eva/Morrow Mountain – Zones E, J, K, N)

Artifact counts in the Late A period lag behind both the Paleoindian (Early Period) and Early Archaic Early Side Notched periods (early part of the Mid Period), when we consider specific periods. If we consider general period counts, however, the Late Period (A and B combined) far outnumber the Early or Mid Period frequencies.

Considering the Late A period alone, an increase is noted in the proportions of various biface categories that are represented, compared to a relative decrease in the proportions of minimally modified flake tools. In other words, while the percentage of the sample comprised of bifaces is comparable to or lower than the percentage noted in earlier periods (among Trimmed Biface I, Trimmed Biface II, and Hafted Bifaces, especially), bifaces appear to increase in representation in comparison to the greatly diminished representation of minimally modified flake tools.

Technological diversity in the Late A period is similar to that seen in the Early Archaic Kirk Stemmed period, which represents a significant drop in diversity from the Paleoindian and

Early Side Notched. Many fewer artifact classes were represented at the beginning of the Late Period.

Bifaces became prominent in the assemblage, comprising the vast majority (75%) of the tools recovered. Trimmed Bifaces (I and II) as well as Hafted and Probable Hafted Bifaces were most common. The Late A period levels produced the greatest number of Early Stage Bifaces, although the sample was still quite small. The numbers of Mid Stage Bifaces had returned nearly to the levels seen in the Paleoindian period. The frequency of bifacial drills remained essentially unaltered. Only a small number of End Scrapers were recovered, and, apart from a single Side Scraper, no other Scraper types were noted. Few other Unifaces were recovered, except for a handful of Perforators (unifacial drills), which had not been found commonly in earlier levels. The numbers of Intentionally Modified Flake tools increased slightly, although their numbers were still lower than those seen in the earlier periods, and the numbers of Unintentionally Modified Flakes diminished notably. Blade tools were nearly absent by this time. While there was some diversity in the toolkit, the frequency of certain tool classes – particularly the formal unifaces and the Unintentionally Modified Flakes – decreased. With the materials from the General levels added in, we see many more Unintentionally Modified Flakes and Trimmed Bifaces, indicating a great emphasis at this time on both refined bifaces and expedient flake tools.

Raw material selection remains unaltered from earlier periods. In the Late A assemblage we see virtually exclusive reliance on Fort Payne chert variants, especially the Blue-Grey type.

A consideration of core production and blank selection revealed that biface flakes continued to be emphasized, along with blocky blanks, and amorphous blanks. Many of those blanks classified as having been derived from “amorphous/multidirectional” cores may actually

have been removed from biface cores, increasing the emphasis placed on biface technology at this time. The proportions of other blank types show no notable changes from the previous period.

Once again, the lack of emphasis on standardized blade production, as seen in the manufacture of blades in the Early period, may have resulted in the production of less standardized implements or may have required the investment of substantial post-detachment modification to make tools with desired characteristics. The increasing emphasis on expedient flake tools, however, may mean that toolmakers were less concerned with producing formal, standardized implements, beyond the production of Hafted Bifaces.

Too few Early Stage Bifaces were recovered to allow an assessment of standardization in measurements, but these tools were discarded at such an early stage in the production sequence that a lack of standardization would not be surprising. Among the Mid Stage Biface specimens, high levels of standardization were noted in all the basic dimensions, suggesting that toolmakers may have been “setting up” these implements as preforms for further reduction into more formal Trimmed Biface and Hafted Biface categories. This pattern likely reflects the relatively small size of the samples as well. The Trimmed Biface I and Trimmed Biface II categories show great levels of variability, which may indicate that modification of proximal dimensions as part of the eventual production of Hafted Bifaces was a greater concern at this stage in the manufacturing process. No discussion of the standardization of Bifacial Drills is presented simply because the sample was too small and too fragmentary to allow any patterns to be discerned.

Only three End Scrapers were recovered from these levels. Two of these were produced from blade-like flakes, while the third was produced from an unknown blank type. All were minimally flaked and yet exhibited high degrees of standardization in Width, Bit Width, and Bit

Angle. Consistency in Width and Bit Width may be a function of their production from blades, although it likely is also related to the small size of the sample. Standardization in Bit Angle may reflect functional concerns or changes related to resharpening or may be related to sample size. All other dimensions were moderately standardized, low or unstandardized, or intentionally different. Only one Side Scraper was recovered, not allowing assessment of standardization in this class.

Several Perforators (unifacial drills) were recovered from the Late A levels, but the sample was too small to allow any assessment of standardization. Too few General Unifaces were available for study, and, regardless, would not have been useful indicators of standardization, given the likely mixed nature of the sub-categories.

All minimally modified flakes (RFL, UFL) exhibited low degrees of standardization in dimensions, or were entirely unstandardized, reflecting the lack of modification applied to these specimens.

Tool condition and use-life/utility, for the Late A specimens is considered together with the Late B tools, below.

Late B (Middle Archaic, Benton – Zone D)

The Late B levels, on their own, produced the lowest number of artifacts. When all the Late levels are considered together, though, frequencies far outnumber those seen in the Early or Mid periods.

Tool diversity dropped dramatically at this time, perhaps signaling a shift in site use from a more generalized residential site in the earlier period to a more specialized activity locus.

Nearly half of the Late B assemblage consisted of Hafted Bifaces, while another 20% comprised Trimmed Biface II specimens. Approximately 10% of the Late B sample consisted of Unintentionally Modified Flakes.

The Late B levels revealed many more biface tools than flake tools. The frequency and proportion of Hafted Bifaces within the Late B assemblage greatly outranked those noted in any other period. Among the flake tool categories, no unifaces were recovered from the Late B levels. The flake tool inventory from these zones, consisted only of minimally modified flakes. While the numbers of Trimmed Biface I and Trimmed Biface II are fewer than those seen in the earlier period, their numbers increase substantially when the tools from the general Late B levels are considered. Fewer Intentionally and Unintentionally Modified Flakes were recovered from this level. Drills and Scrapers disappeared entirely by this time.

No change was noted in raw material selection from the earlier period. Almost all tools were produced from Fort Payne variants, especially the Blue-Grey type.

Consideration of core production and blank selection was difficult, given the paucity of flake tools from this level. The large number of bifaces recovered suggests that biface flakes might have been prime candidates for flake tool production, but so few biface blanks were identified definitively in the flake tool sample that this conclusion cannot be drawn for certain. Of the identifiable flake types, biface, amorphous, and blocky blanks were most common. This pattern is more apparent when the general levels are considered.

Standardization could only be considered for a small number of tool classes, given the fragmentary nature of some classes (e.g., Trimmed Bifaces) or the paucity of examples available for other classes. Moderate to high standardization was noted in all dimensions of the Mid Stage Bifaces, which may indicate their preparation as “preforms,” or may be a function of the small

sample size. The only other tool classes for which standardization could be assessed were the Minimally Modified Flakes. Both the Intentionally and Unintentionally Modified Flake tools exhibit low standardization or an utter lack of standardization in any of their dimensions, reinforcing the expedient nature of their production.

The Late Period assemblage as a whole (Late A and B) produced the greatest frequency of fragmentary specimens from the site. This observation may indicate that Dust Cave was functioning as a manufacturing/retooling locale where used and broken tools were discarded and new ones were manufactured to take their place. Broken, unused implements, in this case, would represent those items broken during manufacture and left at the site. Another possibility is that the fragmentary specimens represent items that were broken on-site, during occupation of the cave, where various residential activities were carried out. The lack of evidence for use of many of the classes of broken tools, in combination with the greatly diminished diversity in the tool assemblage, however, makes this latter possibility less likely.

With the exception of the Early Stage specimens, most of the bifaces recovered were fragmentary. This pattern holds in both the specific and general Late B levels. Lack of evidence for use of the Mid Stage Biface, Trimmed Biface I, and Trimmed Biface II specimens suggest that these artifacts were broken during production rather than during use. One proximal bifacial Drill fragment was recovered, which could point to retooling, as tool users might have retained and transported the broken, hafted fragment in its still-usable haft. This implement could also easily have been broken during use on-site, if the site was, indeed a retooling station, as Drills may have been used in the production of other technology.

Among the small number of Unifaces recovered, nearly equal frequencies of complete/relatively complete and fragmentary specimens were recovered. The fragmentary

specimens included all portions of the tools, suggesting that at least some of these implements would have been used on-site. It is unlikely that broken distal portions would have been transported back to Dust Cave for retooling. Proximal fragments might have been returned to the site, though, especially if they were hafted.

The Intentionally and Unintentionally Modified Flake implements were most often recovered as complete specimens. No evidence exists for repeated resharpening or reuse of these implements, suggesting that they were produced and used expediently on-site.

Little could be said regarding use-life or utility for the Late period specimens for several reasons. First, most of the sample consisted of bifaces, and most of my utility assessment was geared toward understanding changes in unifaces. Second, the majority of bifaces were fragmentary, making it difficult to measure changes through use. Finally, very few unifaces were recovered from these levels, and the ones that were recovered were most often fragmentary, making it difficult or impossible to observe and measure the attributes on these specimens that tend to change through use.

To conclude, several general technological patterns and trends may be identified through time at Dust Cave. The numbers of tools recovered from each period increased through time, suggesting more frequent or more intensive use of the site from the Paleoindian period to the Middle Archaic occupations. Despite an increase in sheer numbers of tools, the assemblage diversity decreased notably. The Paleoindian deposits produced the greatest range of tool types, while the technological inventory had become much less varied by the Middle Archaic. No changes were noted through time in patterns of raw material selection. The specialized blade technology that featured so prominently in the Paleoindian period deposits was abandoned by the

end of the Early Archaic and was replaced by biface cores and less formal cores. Formal Unifaces appear to have fallen out of favor, while bifacial implements became more common. While minimally modified flake tools were used in all periods, they appear eventually to have replaced the unifacial implements in later periods, likely taking up the functional roles once fulfilled by these more formal tools. This possibility will be discussed in greater detail in the following chapter.

Standardization of the various tool classes was difficult to compare through time, simply because the classes for which standardization was easiest to assess (i.e., the formal Unifaces) fell out of fashion. Relatively high degrees of standardization were noted for the End Scrapers from the Early and Mid periods, while the other Uniface categories exhibited less standardization of their measurements. While it is impossible to compare levels of standardization of these implements through time, simply because they were not recovered from the later deposits, the simple fact that standardized and more formal flake tools were abandoned in favor of informal and, therefore, unstandardized tools in later periods is an important shift to note.

The decision to discard implements varied according to tool type. End Scrapers, from the Early and Mid period deposits, appear to have been discarded when the tool was deemed to be unusable (i.e., when the bit angle changed, or when resharpening was no longer possible) and the potential for task failure became too great, rather than when the tool became exhausted. This pattern suggests the possibility of time stress during use. In other words, it appears that the need for usable tools during intensive periods of use was of greater concern to the tool users than was the need for raw material economy. The ease of availability of Fort Payne chert in the region may have contributed to this lack of concern with raw material economy, enabling toolmakers to produce large numbers of tools for use on-site and away from the site. These tools could have

been used to the point of potential task failure, discarded and replaced by new tools. Less distinctive patterning in discard practices was noted for the other scraper types or for the other tools. Many of the less formal tool types appear to have been discarded once their immediate period of use was over, bolstering my assessment of these implements as “expedient” tools that likely were produced, used, and discarded more immediately on the site.

The technological patterns observed at Dust Cave suggest a shift in site use, from use as a general residential site and retooling locale earlier in the occupation sequence to a more specialized locus in the later occupation. The wide variety of tools recovered from the Early and Mid period levels, in various states of repair, hints at the use of Dust Cave as a place to replenish toolkits. In the Early period, especially, occupations appear to have been relatively ephemeral, with the site likely being occupied during times of the year when particular seasonally available resources (e.g., migratory waterfowl) were exploited. A small, mobile group likely stayed briefly at the site to take advantage of the temporary abundance of foods, and used the time to gear-up for the remainder of the settlement-subsistence round. During later occupations we see more intensive use of the site, as indicated by the greater density of artifacts and feature deposits. It appears that Dust Cave became a specialized nut processing locale during the Early Side Notched and Kirk Stemmed periods, as indicated by the prevalence of charred nut shell and nutmeats (Hollenbach 2005, 2009; Carmody 2009), the presence of nut processing tools (Goldman-Finn and Walker 1994; Sherwood et al. 2004), and the appearance of features associated with nut processing activities (Homsey 2004). At this time, technological diversity had decreased dramatically, with cave occupants likely focused more on taking advantage of the abundant mast resources and using simple, easily produced, expedient implements to carry out the majority of tasks at the site. Stone tool production likely remained important during

occupation of the site at this time, as tool-stone is easily available in the immediate area, but the emphasis on tool production seems to have been overshadowed somewhat by the very particular importance of nut processing.

In the following chapter, the lithic analysis is expanded to consider the uses to which these tools were put. In addition to considering various technological patterns, such as blank selection, modification during production, evidence for use and resharpening, degree of exhaustion, and decisions regarding discard, examining tools for evidence of function can provide important insights into the position of the technology in the broader cultural structure. A consideration of tool function may also provide insight into the sorts of technological changes discussed in this chapter, as particular techno-morphological classes may or may not represent the same functional classes across time periods. In other words, the technological changes we witness may be related in part to changes in tool function.

The consideration of technological patterns presented above offered a discussion of how these tools were being produced, how, when, and why they were being discarded, and what sorts of changes they experienced through periods of use. The results of my functional analysis, in the following chapter, allow me to confirm type categories, and to provide insight into the nature of tool use. With an understanding of the uses to which these tools were put, it is possible to tease out the sorts of adaptive challenges that these tasks would have posed. Functional analysis provides insight into those activities being carried out on-site vs. off-site, the sorts of pressures (raw material economy, risk of tool or task failure, etc.) that shaped the technology, and the impact that task performance and tool use requirements would have had on the technological and design processes.

CHAPTER 8: FUNCTIONAL ANALYSIS: RESULTS AND INTERPRETATION

As I discuss the functional analysis results from the Dust Cave lithic assemblage, it is important to bear in mind that microwear analysis is something of an art form rather than a hard science and one that requires the consideration of multiple lines of evidence in constructing a reasonable interpretation of tool function based on observed wear traces. As Driskell (1986: 188) states, “While numerous clues to the specific use of a specimen are provided through physically observable phenomena, interpretation is a matter of assembling these into a logical framework.”

The degree of objectivity and precision that may be attained through the various levels of use-wear analysis has been the subject of debate among scholars (e.g., Bamforth et al. 1990; Grace 1989; Hayden 1979; Keeley and Newcomer 1976; Odell 1975). Much of this debate centered on the relative utility of the low power and high power approaches as well as the utility of macroscopic examination in identifying used edges. Even within any one of these approaches, there has been concern over the qualitative nature and replicability of observations. There is no question that different analysts will observe wear traces differently, a fact attributable partly to the biased lenses through which humans inevitably interpret the world around themselves. What one analyst considers to be “smooth” or “bright” might easily be viewed as “rough” or “dull” by another observer. Regardless, skills tests performed by various researchers (e.g., Driskell 1986; Keeley 1980; Odell and Odell-Vereecken 1980) have demonstrated a fairly high rate of success in the abilities of trained observers to recognize used portions of tools, work actions, and contact materials in their examination of experimentally derived specimens. While it is possible to misidentify patterns, especially if relying only on a single characteristic, combining observations

from various levels of examination enables a more sound and usable interpretation to be developed.

The potentially problematic nature of use-wear analysis is also attributable to the fact that the formation of wear traces does not follow firmly established rules. The development of use-wear depends on a) the nature of the raw material and its resistance or susceptibility to the formation of particular types of wear, b) the nature of the contact material, particularly its density, c) the duration and intensity of use, and d) the conditions present in the surrounding environment, such as the presence of grit or moisture. These variables ensure that, while certain tendencies exist in the formation of wear traces, as confirmed through repeated experimentation (e.g., Keeley 1980; Vaughan 1985), we cannot expect to see identical wear formation in all cases. Successful microwear analysis therefore requires teasing the most probable scenarios from compilations of both macroscopic and microscopic data. The selection procedure employed in this study, adapted from Driskell (1986) and Rigney (2009) and described in Chapter 6 of this volume, facilitates the collection of such multifaceted data. Data collected at the macroscopic, low power, and high power levels, in association with the morphological and technological data discussed in Chapter 7, help to create as complete a picture as possible of design and use in this technological system.

Beyond determining the particular uses of individual implements, use-wear analysis is employed in this dissertation in order to address several other issues. First, by considering degrees of consistency in the wear patterns within so-called “types,” it is possible to assess the validity of the techno-morphological type classifications defined in Chapter 4. Regardless of whether specific wear traces can be interpreted with any certainty, patterning in the types of wear traces noted within certain categories of tools can provide insight into whether those

morphological classes represent internally cohesive functional types. Second, microwear analysis provides insight into the range of activities being performed at Dust Cave through time, and allows interpretation of temporal changes or consistency in site function. Third, and following from the first two points, this approach provides an additional perspective on the patterns noted during my technological analysis (see Chapter 7). Patterns noted in the technological data may be considered in association with the nature of tool function and the range of activities being carried out at Dust Cave in order to shed light on whether changes in individual tool classes represent only changes in tool function, or if they reflect changes in other facets of the culture. Finally, the results of this study allow me to consider whether there are certain tool functions (i.e., tasks) that persist through time but that are performed by different tool types at different times in the site's occupation history. At the outset of this project, my expectation was that those tasks performed by certain categories of formal unifaces, present almost exclusively in the Early and Mid periods, were later being accomplished by less formal flake tools, such as the Intentionally and Unintentionally Modified Flakes (RFL, UFL). Results of my analysis should clarify whether such changes in the assemblage represent a shift in technological organization strategies or a change in site use patterns.

This chapter presents a discussion of the observed use wear patterns by tool class and by general period in order to address questions of how various tool classes were being used through time, how these classes and their uses compared by period, and what functions are represented at different periods through the site's occupation history. Microwear observations for individual specimens discussed in this chapter can be found in Appendix B at the end of this volume. Throughout this chapter, specimens are referenced according to the last five digits of their accession numbers, as listed in the primary data sheets in Appendix A.

ANALYSIS

This microwear study considers several of the classes recovered from the various deposits at Dust Cave. With the exception of the Drill category, the majority of tools studied are unifacial implements. This focus on unifaces was intentional for two reasons. First, most of the bifaces from this site are classified as Hafted/Probable Hafted Bifaces or Stage Bifaces, and previous research on these tool classes has shown that such implements functioned as hafted projectile tips and/or hafted and unhafted knives (e.g., Kay 1996; Meeks 1994: 97; Randall 2002: 92-95; Smallwood 2006). In an attempt to focus this analysis and to devote sufficient time to collecting the most valuable data, a conscious decision was to bypass the bifacial implements, as it did not seem that examination of these tools would have produced enough new information to warrant expending effort on their study. Second, unifacial implements have historically received comparatively less attention in the archaeological literature and, therefore, have great potential to enlighten us about a significant and understudied portion of technological systems. Many of these tools are thought to have been used in tasks that were carried out in a more domestic setting, as opposed to being hunting implements, and therefore can provide insight into work being performed at residential sites, and into the daily lives of prehistoric populations.

Following the initial stages of my microwear selection procedure, as outlined in Chapter 6, a total of 171 tools were identified as being suitable candidates for microscopic examination and functional analysis. This collection of tools includes a variety of Scrapers and Blade Scrapers, Gravers, Perforators, General Unifaces, Intentionally and Unintentionally Modified Flakes and Blades, and both Unifacial and Bifacial Drills. Frequency of specimens in each of these classes, by general time period, is presented in Table 8.1.

The following sections present a detailed discussion of the results of the microwear analysis for each tool category, divided by time period. Results of this analysis are summarized below in Table 8.2. This chart reveals several general patterns in the dataset as a whole. First, scraping is by far the most common work action noted in the sample, and dry hide is the most commonly worked material. Much of this dry hide scraping was accomplished using tools that were identified as End Scrapers. Other tool types were used in transverse actions on both dry hides and harder substances, such as bone and antler. These activities may have included scraping as well as shaving, planing, and whittling. The more formal Scrapers appear to have been utilized in a fairly limited set of tasks, while other Unifaces appear to have been employed for a broader range of purposes.

Several features of Table 8.2 must be discussed briefly. This chart records each instance of an observed wear trace, not simply each tool examined. Some tools that were used for multiple purposes may therefore be represented more than once in this table. Several specimens exhibited evidence for use, but neither the work action nor the contact material could be interpreted with any degree of confidence. These specimens are not recorded in the table but will be evaluated in my discussion of individual tool classes. In other cases, either an action *or* a material could be assigned, but not both. These cases will also be discussed individually in the following sections.

Table 8.1: Microwear Sample Selection: Type Frequencies by Period

Class	Early	Mid	Late A	Late B	TOTAL
ESCR	9	4	3	0	16
BESCR	9	1	0	0	10
SSCR	5	1	1	0	7
BSSCR	2	0	0	0	2
OSCR	5	1	0	0	6
GRV	5	0	0	0	5
SCR/PRF	1	0	0	0	1
SCR/GRV	1	0	0	0	1
TI UNF	4	1	0	1	6
TIII UNF	1	0	0	0	1
? UNF	0	2	0	0	2
RFL	14	15	1	1	31
RBLD	17	1	0	0	18
UFL	21	9	8	5	43
UBLD	7	2	1	0	10
BIF DRL	3	5	1	0	9
UNF DRL	2	0	1	0	3
TOTAL	106	42	16	7	171

ESCR = End Scraper; BESCR = Blade End Scraper; SSCR = Side Scraper; BSSCR = Blade Side Scraper; OSCR = Ovoid Scraper; GRV = Graver; SCR/PRF = Scraper/Perforator; SCR/GRV = Scraper/Graver; TI UNF = Type I Uniface; TIII UNF = Type III Uniface; ?UNF = Unknown Uniface; RFL = Intentionally Modified Flake; RBLD = Intentionally Modified Blade; UFL = Unintentionally Modified Blade; UBLD = Unintentionally Modified Blade; BIF DRL = Bifacial Drill; UNF DRL = Unifacial Drill (Perforator)

Table 8.2: Interpretations of tool function by class and period.

Contact Material			Bone/Antler				Wood	Indeterminate Hard				Dry Hide		FH/ M/B	Soft Plant	Indeterminate Soft			Unidentified Material		
Work Action			Scraping	Incising	Drilling	Multi	Scraping	Scraping	Cutting	Drilling	Incising	Scraping	Cutting	*Butchering	Multi	Scraping	Cutting	Multi	Scraping	Cutting	Multi
SCR	ESCR	E	1									5							1		
		M										3									
		LA										2							1		
	BESCR	E	1									3		1							
		M										1									
	SSCR	E	2																1		
		M																		1	
		LA	1																		
	BSSCR	E												1							
	OSCR	E																	1		
UNF	GRV	E	1	2															1		
	SCR/PRF	E	1					1													
	SCR/GRV	E						1			1										
	TI	E																		1	
		M																	1		
		LB						1				1									
	TIII	E						1													
	Unknown	M																	1		
RFL	RFL	E	2				1					3				1			1		

Table 8.2: Interpretations of tool class and function. (Continued)

Contact Material			Bone/Antler				Wood	Indeterminate Hard				Dry Hide		FH/M/B	Soft Plant	Indeterminate Soft			Unidentified Material		
Work Action			Scraping	Incising	Drilling	Multi	Scraping	Scraping	Cutting	Drilling	Incising	Scraping	Cutting	*Butchering	Multi	Scraping	Cutting	Multi	Scraping	Cutting	Multi
RFL	RBLD	M						2				1		1			1		1		1
		E						2			2	3		2					2		
		M													1						
UFL	UFL	E	1						1			1					1	2	4		
		M	1					1											3		
		LA	1									1	1				1		1		2
		LB						1													1
	UBLD	E												2						1	
		M										1							1		
		LA															1				
DRL	Bifacial	E			1																
		M			2					2											
	Unifacial	E								1											
		LA			1																

Notes: E=Early; M=Mid; LA=Late A; LB=Late B; FH/M/B=Fresh Hide, Meat, and Bone polish. Certain tools showed evidence for use on more than one contact material and/or in more than one work action. The numbers presented above denote how many times those polishes and actions were noted, not the number of tools that were examined. One tool may be recorded twice, with the different actions and polishes recorded separately.

SCR = Scraper; ESCR = End Scraper; BESCRA = Blade End Scraper; SSCRA = Side Scraper; OSCRA = Ovoid Scraper; UNF = Uniface; GRV = Graver; SCR/PRF = Scraper/Perforator; SCR/GRV = Scraper/Graver; TI = Type I Uniface; TIII = Type III Uniface; RFL = Intentionally Modified Flakes; RBLD = Intentionally Modified Blade; UFL = Unintentionally Modified Flake; UBLD = Unintentionally Modified Blade; DRL = Drill.

Scrapers (SCR)

This broad category includes several morphologically distinct sub-classes, which appear to correspond to differences in function. This general category encompasses End Scrapers, Blade End Scrapers, Side Scrapers, Blade Side Scrapers, and Ovoid Scrapers. Humpback scrapers are absent from this analysis, as none of the specimens passed the first stage of the stepwise selection process, described in Chapter 6.

While Blade Scrapers have been considered separately in this dissertation, because of their unique mode of production and resultant distinctive morphological characteristics, and while they were treated as distinct subclasses, they were considered in conjunction with their non-blade counterparts in order to assess whether the selection of blade flakes over other flake types coincides with differences in functional applications.

End Scrapers (ESCR)

Sixteen (n=16) End Scraper specimens were selected for microwear analysis. This sample, which consisted of tools produced on a variety of blank types, included 9 Early period, 4 Mid period, and 3 Late A period scrapers.

Of the 9 Early period specimens, two (n=2; Acc. Nos. 10296, 17879) possessed indeterminate wear traces, perhaps having been used briefly enough or on soft enough materials that no identifiable wear traces formed. Among the tools with distinctive wear patterns, five (n=5) were used in scraping dry hides (Acc. Nos. 11430, 11438, 11566, 13903, 11427; Figures 8.1, 8.2). Stereoscopic examination revealed edge rounding and abrasion, as well as mostly feather-terminated microflakes that were restricted primarily to the dorsal surface of the working edge. During the incident light examination, transverse striations were noted, as well as the dull,

rough, pitted polish that is characteristic of working dry hides. One tool (Acc. No. 10294) was used to scrape bone/antler. In addition to sporadically distributed patches of bright, pitted polish characteristic of working bone, examination of this tool showed transverse striations, multiple microscopic step fractures, and a relatively sharp distal edge margin. Another single implement (Acc. No. 11408) was utilized in a transverse action on an unidentified material. While striations were observed running perpendicular to the distal edge, no polish could be identified. All edge margins were quite sharp, exhibiting no evidence for wear as a result of use. At the proximal end of the tool, a break in outline morphology was accompanied by significant crushing observable at the stereoscopic level. This crushing is interpreted as haft wear.



Figure 8.1: Dry hide polish on End Scraper. (L) Specimen 11438 with circle indicating location of wear. (R) Dry hide polish and transverse striations on ventral surface (magnification 100x).



Figure 8.2: Dry hide polish on End Scraper. (L) Specimen 11430 with circle indicating location of wear. (R) Dry hide polish, abrasion, and transverse striations (magnification 100x).

One of the Mid period specimens (Acc. No. 10387) was either unused or used so lightly that no wear traces formed. The remaining three (n=3) Mid period specimens (Acc. Nos. 10279, 10326, 11557; see Figure 8.3) were used to scrape dry hides. Each revealed significant edge rounding in stereoscopic examination as well as several step-terminated microflakes on the dorsal surface of the working edge. Incident light examination revealed transverse striations and dull, rough, pitted polish. Specimen 11557 exhibited significant edge crushing at the proximal end of the tool, suggestive of hafting.

All three (n=3) Late A period specimens (Acc. Nos. 10843, 11494, 13648) appear to have been used to scrape dry hides, although the wear patterns noted on one specimen were a little less definitive than on the others. Each of these tools exhibited edge rounding and transverse striations. Dull, pitted polish and micro-step fracturing were also noted on the working margins

of two of these specimens (Acc. No. 10843, 13648,). Specimen 11494 produced only a band of generic-weak polish along the distal margin, but the other two tools possessed patches of the definitive dull, pitted polish characteristic of working dry hides.



Figure 8.3: Characteristic hide polish ribbon on End Scraper. (L) Specimen 11577 with circle indicating location of wear. (R) Hide polish ribbon (100X).

My analysis suggests that those tools identified as End Scrapers were primarily used to scrape dry hides, which involves stretching and drying a hide prior to removing the grain with a sharp tool that is pulled across the surface of the hide. Dry hide scraping entails certain advantages in the tanning process (see discussion in Chapter 9; Edholm and Wilder 2001) that may compensate for the additional time required for preparing the hide. This particular form of hide preparation may have occurred during periods of down-time, after the intensive hunting and initial processing period.

No changes in function are noted through time, although formal End Scrapers do seem to drop out of favor by the latter part of the Early Archaic, making assessments of temporal change difficult. More illuminating will be a consideration of the other tool categories, which may serve to demonstrate what other tools were assuming the function of these implements in later periods. All of the specimens examined here appear to have served only a single purpose.

Blade End Scrapers (BESCR)

Blade End Scrapers exhibit the same distal retouch that characterizes the non-blade specimens, but these tools were all produced from specially manufactured blade flakes. A total of ten (n=10) specimens were subjected to microwear analysis, including nine (n=9) from the Early period levels and one (n=10) from the Mid period levels.

Of the Early period specimens, one (Acc. No. 18004) revealed indeterminate wear traces, suggesting either a lack of use, recent resharpening, or use on soft enough substances that wear did not form. Of the remaining Early tools, six (n=6) were used in transverse (scraping) work actions. Three of these (Acc. No. 11549, 11575, 13750) are interpreted as having been used to scrape dry hides, as they exhibited transverse striations, significant abrasion/edge rounding, and dull, rough, pitted polish. Microflaking, including feather and step-terminated examples, tended to be restricted to the dorsal surfaces of the working edges. Two others (Acc. No. 10354, 10907) were scraping implements, with transverse striations on the distal margin, which revealed both dull, rough, dry hide polish and bright, rough bone/antler polish. A single specimen (Acc. No. 11568) was used in a scraping action, but the contact material could not be determined. One of the Early period tools (Acc. No. 11574), originally identified as an End Scraper, showed evidence for *cutting* dry hide rather than scraping. Examination of this tool revealed the dull,

rough, pitted polish characteristic of contact with dry hide. However, this polish, which was located along the right tool margin, was accompanied by longitudinal rather than transverse striations. One final Early period Blade End Scraper (Acc. No. 17992) seems to have served as a multipurpose implement, with evidence for scraping dry hide and for cutting fresh hide. The distal margin showed transverse striations and dull, rough polish, while the straight right lateral margin showed bifacial, feather-terminated microflaking, no striations, and a continuous, dull, “greasy” polish ribbon along the length of the margin.

Only one (n=1) Mid period specimen (Acc. No. 11504) proved to be suitable for microwear analysis. This tool exhibited micro-step fracturing along the length of the distal margin, as well as light edge rounding. While no identifiable polish was detected, transverse striations were visible through the incident light microscope. The transverse striations, in association with edge rounding and dorsal microflaking may hint that this tool was used to scrape dry hides.

With only a single specimen studied from the Mid period levels, it is impossible to make any statements regarding changes or consistency through time in the function of the Blade End Scrapers. Taking the sample as a whole, however, it appears that these pieces were used primarily as dry hide scraping tools but that they also appear to have been applied more regularly to a wider variety of tasks than were the End Scrapers produced on other blank types. In addition to scraping dry hides, the BESCR category produced evidence for use in whittling bone/antler and for use as multipurpose implements.

Side Scrapers (SSCR)

Side Scrapers are those tools that exhibit a relatively steep working edge along one or both lateral margins. The tools studied here are those specimens that were produced on a variety of non-blade flakes. A total of seven (n=7) specimens were deemed suitable for microwear analysis: five (n=5) from the Early period, one (n=1) from the Mid period, and one (n=1) from the Late A period.

Among the Early period specimens, two (n=2; Acc. Nos. 13742, 17111) possessed wear traces that could not be identified and likely represent tools that either were used only minimally or were used on substances soft enough that wear did not form. Three (n=3) of the remaining specimens were used in scraping various materials: two were used on bone/antler (Acc. Nos. 11518, 13907) and one on an unidentified substance (Acc. No. 10359). The two tools interpreted as having been used to scrape bone/antler exhibited bright polish, both rough and smooth, as well as striations that ran transverse to the lateral margins. Microflaking, both feather and step, was noted on both of these specimens, and edges tended to be relatively sharp. One specimen (n=1; Acc. No. 10359) exhibited striations transverse to the left lateral margin, but polish formation was minimal and could only be classified as generic-weak.

The single Mid period specimen (n=1; Acc. No. 10222) appears to have been used to cut an unspecified material and exhibited evidence for hafting. This tool showed transverse striations and generic-weak polish near the proximal end, in the region interpreted as the haft. In addition, this tool exhibited feather-terminated microflakes along the dorsal and ventral surfaces of the edge margins, distally from the haft area. More microflakes were noted along the dorsal surface than the ventral surface, suggesting that this tool may have been held at an angle during use.

Traces on the Late A period specimen (n=1; Acc. No. 10325) suggest its use in scraping or whittling bone/antler. Transverse striations were noted along the left lateral margin, in association with bright, rough polish and rounding of the arrises. Step fracturing noted along the left margin at the macroscopic level also hints at the use of this tool in working hard substances.

Scraping or whittling bone or antler was a commonly observed function of the Side Scrapers. This suggests that “Side Scrapers” may actually have been used in the capacity of spokeshaves or draw-knives, likely in the production of other technological elements (e.g., foreshafts, handles, etc.). The one tool that exhibited evidence for cutting is perhaps better labeled as a unifacial knife.

Blade Side Scrapers (BSSCR)

Only two specimens produced enough macroscopic wear traces during the stepwise selection process to warrant examination at higher magnifications. Both of these items were recovered from the Early period levels. One (Acc. No. 17113; Figure 8.4) exhibited both feather and step-terminated microflakes, as well as bone polish, generic weak polish, and multidirectional striations, suggesting its use as a butchering implement. This tool also exhibited wear patterns suggestive of hafting. The other specimen (Acc. No. 15342; Figure 8.5) exhibited no interpretable use-wear traces but does appear to have been hafted. Crushing along the left and right lateral margins near the proximal end, along with bright, rough polish, multidirectional striations, and rounding of the dorsal flake scar ridges all hint at the possibility that this specimen may represent the haft end of an otherwise broken tool. Movement in a haft, perhaps made of a hard substance such as bone or wood, could account for the presence of these wear traces.



Figure 8.4: Greasy polish on Blade Side Scraper. (L) Specimen 17113 with circle indicating location of wear. (R) Greasy polish (magnification 200x).



Figure 8.5: Polish and rounding on flake scar ridges on Blade Scraper. (L) Specimen 15342 with circle indicating location of wear. (R) Bright polish and rounding of dorsal flake scar ridges (magnification 100x).

Side Scrapers, whether produced from blade flakes or other blank types, appear to have been used as either in whittling bone or antler, or as hafted cutting tools. The tools in this category might therefore be more appropriately reclassified as spokeshaves/drawshaves and knives.

Ovoid Scrapers (OSCR)

The Ovoid Scrapers are those specimens that were ovate in outline form and were worked around the circumference of the tool. Six specimens were identified as being candidates for microwear analysis: five (n=5) from the Early period levels, and one (n=1) from the Mid period levels.

Among the Early period specimens, few microwear traces were noted. One specimen (Acc. No. 13852) exhibited transverse striations suggestive of a scraping motion, but the dull, rough, poorly developed polish could not be interpreted with any certainty. Another specimen (Acc. No. 13850; Figure 8.6) appears to have been used to work fresh hides, as suggested by the presence of dull, poorly linked, greasy polish along the right lateral margin. The associated work action could not be interpreted. One scraper (Acc. No. 11514) exhibited continuous but poorly linked and dull polish on the high points of the microtopography along the left margin. A definitive interpretation of this polish could not be made, but it likely represents use in working a soft material, such as meat or fresh hide. The associated work action could not be determined. The remaining two tools (Catalog numbers: Acc. No. 10912, 13912) exhibited no wear traces at all and may have been unused or resharpened soon before discard.

The single Mid period specimen (Acc. No. 13698) was used only minimally, perhaps having been produced or resharpened immediately prior to discard. While this specimen

exhibited a suite of wear traces, including microflaking, minor edge rounding, and some poorly-linked polish, these traces were not sufficient to permit interpretation of either the work action or the contact material. It is conceivable that this tool was used on a soft enough substance that wear traces simply were slow to form.



Figure 8.6: Greasy polish on Ovoid Scraper. (L) Specimen 13850 with circle indicating location of wear. (R) Greasy, diffuse polish (magnification 200x).

Among the Ovoid Scrapers, a clear emphasis is noted on working soft materials. The majority of these implements were used in a transverse (scraping) motion, as opposed to a longitudinal (cutting) motion. Some of the wear traces suggest that they may have been used in the processing of fresh hides rather than dry hides. Their paucity relative to the frequency of End Scrapers may speak to the relative emphasis on processing stored hides during periods of downtime, rather than processing hides immediately following butchery.

Unifaces

Several other categories of unifacially worked implements were examined for microwear traces. These categories include Gravers (GRV), Perforators (PRF), some combination tools, and a variety of general Unifaces (UNF). The morphological variety represented in this general class corresponds to great variety in apparent tool functions.

Gravers (GRV)

Gravers were identified by the presence of at least one short, thick, steeply flaked protuberance on at least one flake margin. Six (n=6) of the graver specimens were identified as suitable candidates for microwear analysis, and all six were recovered from Early period deposits. Two of the six (n=2; Acc. Nos. 15297, 15387) exhibited wear traces that could not be assigned to any particular work action or contact material, either because they had not been used or had been resharpened prior to discard, or because they were used only briefly or on particularly soft materials. These two tools possessed only very weak polish, with no other distinctive wear traces visible. The remaining four specimens were used primarily for working bone/antler. Two of these (n=2; Acc. Nos. 10918, 11547) appear to have been used in incising these hard materials. One specimen (Acc. No. 10918; Figure 8.7) exhibited bifacial stepped microflaking near the tip of the graver spur, as well as dull, poorly linked patches of polish on the high points of the microtopography. This polish is visible on both the dorsal and ventral surfaces of the tip, suggesting that both faces contacted the worked material, as would occur during a back-and-forth incising action. The third tool (Acc. No. 11429) appears to have been used in a scraping/whittling motion. Rough, pitted polish was noted on this specimen, in association with striations that were perpendicular (transverse) to the working edge. Another

tool (Acc. No. 10364) exhibited wear consistent with use in a transverse motion on an unidentifiable substance. This specimen possesses two protuberances, initially interpreted as graver spurs. In light of the visible wear traces, though, it appears that this tool may have functioned as a spokeshave, with the spurs representing the outer margins of the spokeshave concavity.

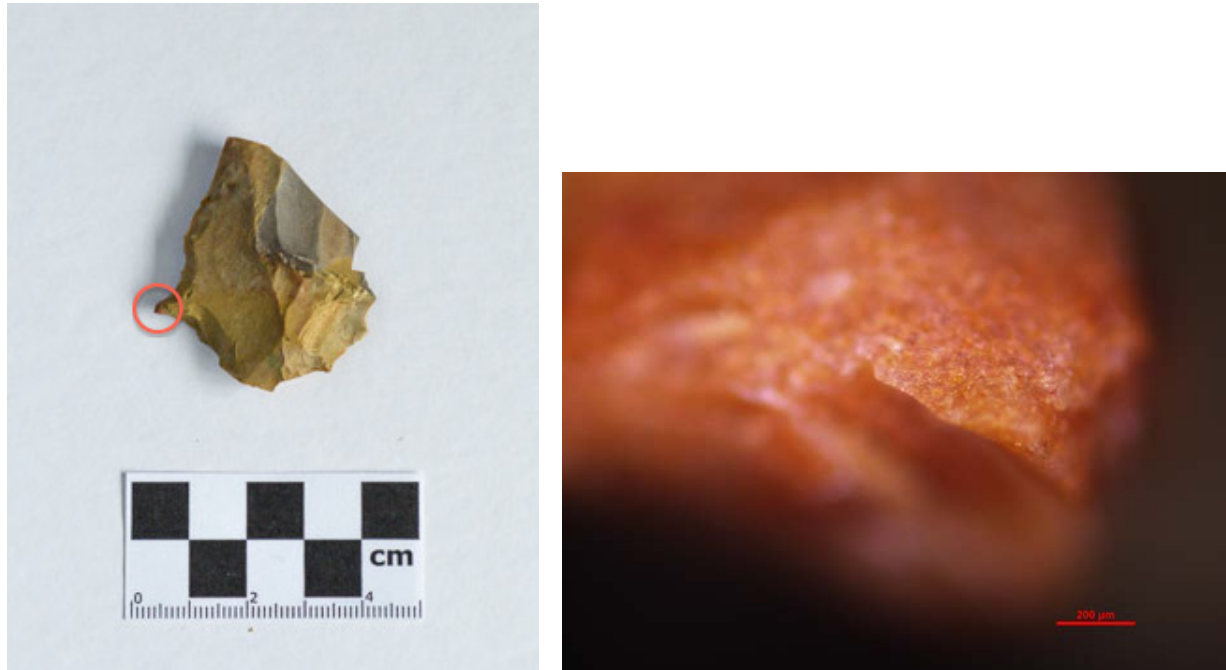


Figure 8.7: Graver tip with step fracturing and reddening. (L) Specimen 10918 with circle showing location of wear. (R) Thermal color change from friction (?) and step fracturing on tip (magnification 50x).

All of the implements identified as Gravers seem to have been used in working hard substances, through actions such as engraving or whittling. Temporal changes cannot be assessed because all of the specimens selected were derived from the Early period deposits. This pattern does beg the question of what changed. Did other tools begin to fulfill the roles of these

engraving implements, or did functional needs change, perhaps with bone/antler falling out of favor as a worked material? These possibilities will be considered in greater detail later.

Scraper/Perforator (SCR/PRF)

A single combination Scraper/Perforator specimen (Acc. No. 10908) from the Early period was deemed suitable for microwear analysis. This specimen exhibited microflaking around its circumference, with all damage restricted to the dorsal surface. The distal margin exhibited pronounced edge rounding, with polish on both the dorsal and ventral surfaces. This polish is dull and rough on the dorsal surface but much brighter on the ventral face of the distal margin as well as near the peak of the convexity on the dorsal surface, where it was observed to be somewhat greasy in appearance. The left tool margin, which is concave, exhibited bright, pitted polish and striations transverse to the edge. Wear patterns on this tool are consistent with using the distal margin to scrape hides, perhaps fresh and/or dry, and working bone with the concave left tool margin. While an apparent perforator spur was noted, no wear traces were detected on this feature. This tool has the appearance of an End Scraper that became damaged and repurposed for another task, specifically whittling bone/antler.

Scraper/Graver (SCR/GRV)

A single combination Scraper/Graver specimen (Acc. No. 11569) from the Early period was selected for microwear analysis. This tool was used to work dry hide, likely in a transverse (scraping) action, although directionality was somewhat difficult to interpret. The distal margin exhibited plenty of micro-step fracturing and sporadic patches of dull, rough polish. In addition to scraping, this tool also appears to have been used to incise or engrave a hard substance, using

the short, thick protuberance that was interpreted as a graver tip. Much micro-step fracturing was noted along this tip, suggesting use on a hard substance, but the specific material could not be interpreted.

General Unifaces (UNF)

While the General Uniface category included several varieties (Type 1, Type 2, Type 3, and Unknown/Type 4), only specimens from the Type 1 (single-edged unifaces), Type 2 (multi-edged unifaces), and Unknown (Type 4) general uniface categories were selected for microwear. The Type 3 category was interpreted as representing haft portions of completely dorsally flaked End Scrapers. Apart from haft wear, examination of this category likely would have been fruitless. Selected for study here were six (n=6) T1 Unifaces, one (n=1) T2 specimen, and two (n=2) Unknown specimens.

The Type 1 specimens examined included four (n=4) from the Early period, one (n=1) from the Mid period, and one (n=1) from the Late B period. Of the four Early specimens, only one (Acc. No. 13744) produced interpretable wear traces and seems to have been used to cut an indeterminate contact material. While no striations were noted, microflaking on both the ventral and dorsal faces of the used margin hints at a longitudinal motion. The lack of polish on this tool means that the contact material may not be interpreted with any certainty. The remaining three specimens from the Early period (Acc. Nos. 10374, 13743, 13909) do not exhibit any interpretable wear traces and may not have been used at all. The single Mid period specimen (Acc. No. 13691) may have been used in a transverse motion, based on the presence of only unifacial microflaking, but the contact material could not be assessed. The solitary Late B period specimen (Acc. No. 11403) showed dull, rough polish characteristic of working dry hides. This polish was accompanied by transverse striations indicative of a scraping action.

The single Type 2 specimen (Acc. No. 11350), recovered from the Early period levels, showed evidence for working a hard material in the notched area of the tool. Examination of the notch revealed significant step fracturing, as well as patches of generic-weak polish, which may signify that the hard material being worked was removing microflakes faster than the polish could develop. The specific contact material could not be determined.

Two Unknown Unifaces were studied from the Mid period levels. One of these tools (Acc. No. 13886) appears to have been used to scrape an unknown substance. Transverse striations were indicative of a scraping motion, but the nature of the contact material could not be determined, given the lack of polish formation. The other Unknown UNF specimen (Acc. No. 11415) did not produce any identifiable traces of work action or contact material but did show wear suggestive of hafting (weak polish in combination with transverse striations near the midpoint of the left margin).

The sample of Unifaces studied produced evidence for use in a wide array of activities, matching the technological and morphological variability seen in this general category. Gravers appear to have been used in the Early period almost exclusively and were employed in incising or whittling hard substances such as bone and antler. Even the combination Scraper/Graver from the Early period was employed partly in engraving a hard material but also appears to have been used in scraping dry hides, mirroring the function of single purpose End Scrapers from the earlier deposits. Among the several categories of general Unifaces, little patterning in function was noted. Evidence of cutting, scraping, working hard materials, and even scraping dry hides was recorded. It appears that the tools that received more intentional modification, and that exhibited more formal morphological characteristics, were being designed for dedicated use in specific tasks. The less formal tool categories seem to have been used to fulfill a wider variety of

functions. While this observation might call into question the sub-type categories established for the general Unifaces, those tools were partitioned only on the basis of the number of modified edges that were noted, a characteristic in no way meant to imply function.

Intentionally Modified Flake Tools

This category of minimally but purposefully modified tools includes a sub-set produced on blade flakes and one produced on a range of other flake types. Modification tends to be less extensive than on the more formal unifacial tools, having been applied only to alter edge morphology or angle very slightly and to make the flake suitable to the task immediately at hand. The blades and other flake types are considered separately.

Intentionally Modified Flakes (RFL)

This morphologically variable class of implements comprises flakes that were selected for minimal modification and appear to have been used briefly and discarded almost immediately. They were selected from among a varied assortment of flakes, perhaps the by-products of other tool manufacture, and exhibit little evidence for reuse or resharpening.

Thirty-one (n=31) specimens were selected for microwear analysis from among a large collection of RFL tools. This sample includes fourteen (n=14) from the Early deposits, fifteen (n=15) from the Mid levels, one (n=1) from the Late A period, and one (n=1) from the Late B levels. These tools appear to have been used in a wide variety of tasks, exhibiting varied traces of work actions and contact materials. The unpatterned and often minimal appearance of the wear traces on these tools emphasizes their likely expedient nature.

Among the fourteen (n=14) Early period specimens, six (n=6; Acc. Nos. 14646, 15290, 15362, 15375, 15401, 18007) exhibited wear traces that could not be assigned to either a work action or a contact material. Three (n=3) of the Early period specimens exhibited dry hide polish. Two of these (n=2; Acc. Nos. 13723, 13759) were used to scrape hides, as indicated by the presence of transverse striations, while the work action of the third (Acc. No. 11352) was unidentifiable. Several of these flake tools were used in scraping other substances as well: two bone/antler (n=2; Acc. Nos. 11398, 15289) and one unidentified soft material (Acc. No. 11571). One specimen (Acc. No. 13734) produced evidence for scraping varied substances, particularly wood and dry hide. Transverse striations, accompanied by patches of bright, smooth polish and rough, pitted polish, hint at these uses. Another single specimen (Acc. No. 11565) was used to work a soft substance, although the work action could not be interpreted with any certainty.

Of the fifteen (n=15) Mid period specimens studied, the work actions and contact materials of five (n=5) could not be interpreted (Acc. Nos. 10224, 11414, 13919, 14633, 15321). These specimens do, however, appear to have been utilized in some capacity, perhaps on very soft materials, or for such short periods of time that wear patterns did not form. Several tools were used in transverse actions (scraping) on a variety of substances. One specimen (Acc. No. 11502) may have been used to scrape dry hides. While transverse striations provided clues to the work action, the remaining wear traces were somewhat ambiguous, consisting of edge rounding but no polish. One other (Acc. No. 10395) appears to have been used in a transverse action on an unknown hard substance, as suggested by the presence of transverse striations and patches of substantial crushing. Another two specimens (Acc. Nos. 10234, 11491) seem to have been used to scrape unknown substances. Transverse striations on both of these tools indicate a scraping motion, but the absence of identifiable polish does not allow contact material to be interpreted.

Two tools (Acc. Nos. 10433, 13924) exhibit evidence for use in both scraping and cutting actions, and another (Acc. No. 15282) is interpreted as a possible butchering implement. Examination of each of these tools revealed multidirectional striations as well as evidence for use on a variety of substances (crushing indicative of use on hard materials, generic weak polish suggestive of use on soft materials). One tool (Acc. No. 11541) was used to cut an unidentified substance. This specimen showed both dorsal and ventral microflaking along the used margin, as well as mild edge rounding. The remaining two tools were used to work wood (Acc. No. 13702) and an unidentified hard material (Acc. No. 11498), but work action could not be determined. Specimen 13702 showed a patch of smooth, bright polish with a mounded appearance, characteristic of working wood, while specimen 11498 exhibited significant edge crushing but no identifiable polish.

The single Late A period specimen (Acc. No. 14842) appears to have been modified in anticipation of use but did not exhibit any identifiable wear traces. Similarly, no wear traces were noted on the single Late B specimen (Acc. No. 11297). These tools may not have been used, or may have been used minimally or on soft enough substances that wear traces did not form.

Many of these minimally modified flake tools were used in transverse work actions (i.e., scraping, whittling, shaving), most often on dry hides, bone/antler, and wood. These activities and materials mirror the range of activities being performed with the more formal unifacial implements that were in use through the same periods. By the Mid period, a much broader range of uses is represented, when compared with the emphasis placed on scraping and hide working in the Early period. Nothing can be said about the use of these implements in the latest periods of occupation, as specimens from these periods produced no identifiable wear traces.

Intentionally Modified Blades (RBLD)

These tools were produced in the same way as the Intentionally Modified Flakes, with portions of the edges having been modified purposefully. The difference lies in their production on blade flakes rather than on other flake types. Eighteen tools (n=18) were selected for microwear analysis: seventeen (n=17) from the Early period levels, and one from the Mid period levels. Those specimens examined from the Early period deposits exhibit evidence for use in a wide variety of tasks. The range of tasks represented in this class of artifacts is broader even than the range noted among the non-blade flake specimens.

Among the Early period tools that were examined, four (n=4) were modified but did not produce any interpretable wear traces (Acc. Nos. 10356, 10361, 10943, 17082). Another specimen was used, but neither contact material nor work direction could be assigned with certainty. One of these Early specimens was used to scrape dry hides (Acc. No. 11400), and another (Acc. No. 10555) showed dry hide polish, but the direction of use could not be interpreted. Both of these tools exhibited the edge rounding and the dull, rough, pitted appearance that characterizes dry hide polish, but only one showed transverse striations indicative of directionality. Another specimen (Acc. No. 13942) was used in a scraping motion, based on the presence of transverse striations, but the contact material could not be determined.

Several of the Early period tools appear to have served multiple purposes. Two of these (Acc. Nos. 11511, 11516) exhibited evidence both for scraping dry hide and scraping unidentified hard substances. These tools exhibited margins with edge rounding and the characteristic dull, rough dry hide polish, as well as relatively sharp margins covered in step fracturing and little polish. The latter suggests working harder materials. Another apparently multipurpose implement (Acc. No. 10345) was used to cut and scrape, as suggested by the

presence of multidirectional striations as well as rough polish and generic weak polish. Three tools (n=3; Acc. No. 10336, 10536, 11577) appear to have served multiple functions. Two of these (Acc. Nos. 10336, 10536) appear to have served as scraping and engraving tools. Both exhibited short, thick graver spurs with significant crushing and abrasion, suggesting use on hard substances. Each of these tools also revealed transverse striations on one of their margins, indicative of use in a scraping motion, accompanied by rough polish. The presence of longitudinal striations on another specimen (Acc. No. 11577) suggest that it was used in a cutting motion, and the observed bright, smooth and more mounded bright polishes suggest use on both bone and wood. Other patches of generic weak polish were noted as well. This tool is interpreted as a multipurpose implement that may have been used, for at least some of its life, as a butchering tool.

Two other specimens (Acc. Nos. 10362, 11561) worked unidentified hard materials, as suggested by the presence of significant degrees of edge crushing and dulling, but the work actions could not be interpreted. Specimen 10362 exhibited a pair of protuberances with a notch between them. The significant edge crushing on only the dorsal face suggests this portion of the tool may have served to work a hard substance in a transverse motion, perhaps functioning as a spokeshave. The proximal portions of both of these tools revealed very localized transverse striations, edge rounding, and a few patches of generic weak polish. Given the location and limited distribution of this wear, it is interpreted as possible evidence for hafting. Finally, two specimens (Acc. Nos. 11563, 11545) exhibited only haft wear, including limited distributions of transverse striations and bone or wood polish at their proximal ends. These items may represent the haft ends of broken implements.

The single Mid period specimen (Acc. No. 13874) represents the only tool examined that showed good evidence for working soft plant material. The polish noted along the left margin is smooth, rounded, moderately bright, and mounded and stretches beyond the edge of the tool onto the tool surface. This implement seems to have been used in both transverse and longitudinal motions, based on observed multidirectional striations.

The Intentionally Modified Blades were utilized in a wide variety of activities including cutting, scraping, butchering, and engraving and appear to have worked both hard and soft substances. Little patterning is noted in the range of activities in which these tools were utilized, lending support to the argument that they represent expedient implements that were drafted into service for use in any number of tasks. With no evidence for successive resharpening episodes or extended periods of maintenance, it is likely that these tools were utilized and discarded fairly rapidly. The two tools with evidence for haft wear may be exceptions and are perhaps more appropriately classified in the category of general Unifaces. With only one Mid period tool having produced sufficient wear to warrant examination, it is impossible to make any statements regarding change or continuity over time in the use of these tools.

Unintentionally Modified Flake Tools

The tools included in this category are items that were utilized but were not modified intentionally. Instead, these simple flakes became damaged incidentally during use in a variety of tasks. It is likely that these implements were used in an expedient manner, fulfilling a variety of immediate needs for tool users. The blade flakes and other flake types are considered separately, given the unique production strategy for the blades.

Unintentionally Modified Flakes (UFL)

A total of forty-four (n=44) specimens in the non-blade flake category were subjected to microwear analysis. Twenty-one (n=21) of these were recovered from the Early period levels, nine (n=9) from the Mid period deposits, eight (n=8) from the Late A levels, and five (n=5) from Late B period. As with the Intentionally Modified Flake tools, a wide range of activities is represented in the wear traces among these items. Several of these implements served as multipurpose tools, exhibiting more than one set of wear traces per tool. These items are interpreted as expedient implements that likely were selected and utilized to fulfill an immediate need, then discarded after use with no concern given to revitalizing or maintaining the tool.

Of the Early period specimens, six (n=6; Acc. Nos. 13791, 13899, 15131, 15250, 15327, 17996) could not be assigned to either a work action or a contact material, despite exhibiting evidence for use. The remaining sixteen (n=16) specimens showed clearer evidence for use on particular contact materials or in particular work actions.

Eight specimens were used in scraping motions on a variety of contact materials. Two of these (n=2; Acc. Nos. 10421, 11586) were used to scrape dry hide, as indicated by the presence of transverse striations, significant edge rounding, and dull, rough polish. Two other tools (n=2; Acc. Nos. 10533, 17116) are interpreted as having been used to scrape bone/antler, as they exhibited transverse striations, some edge crushing, and bright, rough polish. The contact materials that were worked by the remaining four scraping tools (n=4; Acc. Nos. 13667, 13758, 13765, 15408) could not be identified. The presence of transverse striations, though, spoke to the work action. Another single specimen (Acc. No. 15113) revealed significant edge rounding and possible dry hide polish, but the work action could not be determined.

Three of the Early period tools were used in a longitudinal (cutting) motion, but contact materials were more difficult to identify. One of these (n=1; Acc. No. 17129) seems to have been used to cut a soft material, an interpretation based on the presence of bifacial edge damage and poorly formed polish along the right margin. The other two specimens (n=2; Acc. No. 15834, 17907) appear to have been used to cut harder substances, based on the presence of longitudinal striations, bifacial edge damage, and significant micro step fracturing along the used margins.

Two specimens (n=2; Acc. No. 13664, 15364) exhibited evidence for use in various work actions on soft substances. Examination of these tools showed multidirectional striations but only very generic, weak, poorly linked polish. Finally, another specimen (n=1; Acc. No. 11542) was used on a soft material but the direction of use could not be ascertained. Fine, continuous, feather-terminated microflaking was noted along the margins of this tool, but no striations were noted, and no polish had formed.

Among the Early period specimens, there is a fairly heavy emphasis on scraping various substances, especially dry hide and bone/antler. This mirrors the general patterns seen among the various Early period unifacial implement classes. Other activities certainly are represented, but in much lower frequencies.

Three of the Mid period specimens (n=3; Acc. Nos. 14701, 15164, 15250) exhibited wear patterns that could not be assigned to a particular work action or contact material, but the macroscopic damage did suggest that they were utilized. Among the remaining Mid period specimens, there is a general emphasis on scraping as a work action. Three tools (n=3; Acc. Nos. 10239, 15199, 15261) exhibited evidence for transverse actions without any associated polish. Another specimen (Acc. No. 14699) seems to have been used in scraping a harder substance, as suggested by the presence of step terminated microflakes and transverse striations. One tool

(Acc. No. 17148) revealed transverse striations and patches of smooth, bright polish, suggestive of whittling bone or antler. One specimen (n=1; Acc. No. 15302) exhibited dull, rough, dry hide polish, but the direction of use could not be interpreted.

In the Late A period, the earlier emphasis on scraping appears to have diminished, being replaced by a much broader range of activities. Only one of the Late A specimens (Acc. No. 14662) could not be assigned to either a work action or contact material, despite showing evidence for having been used. Cutting actions were observed on two of the specimens studied. One tool (Acc. No. 15099) revealed dry hide polish but had clearly visible longitudinal striations suggestive of cutting. Such an implement might have been used in the manufacture of items from processed dry hides (e.g., clothing, bags, shelters). Another (n=1; Acc. No. 15023; Figure 8.8) was classified as a butchering implement, as it exhibited longitudinal striations indicative of cutting, as well as fine, feather terminated microflaking typical of working softer materials and isolated patches of bright, rough polish that had the appearance of bone polish.

Scraping actions were noted on four of the tools examined. Two of these (n=2; Acc. Nos. 10621, 15124) exhibited transverse and/or oblique striations but did not produce identifiable polish. One tool (Acc. No. 10788) is interpreted as having been used to scrape an unknown material. This tool exhibited oblique striations, and patches of smooth polish. Another specimen (Acc. No. 10691) appears to have been used to scrape a relatively soft material. This tool exhibited transverse and oblique striations and generic-weak polish, restricted primarily to the dorsal surface. While this may represent scraping of a soft substance, it may also indicate relatively minimal use that did not allow enough time for polish to form.

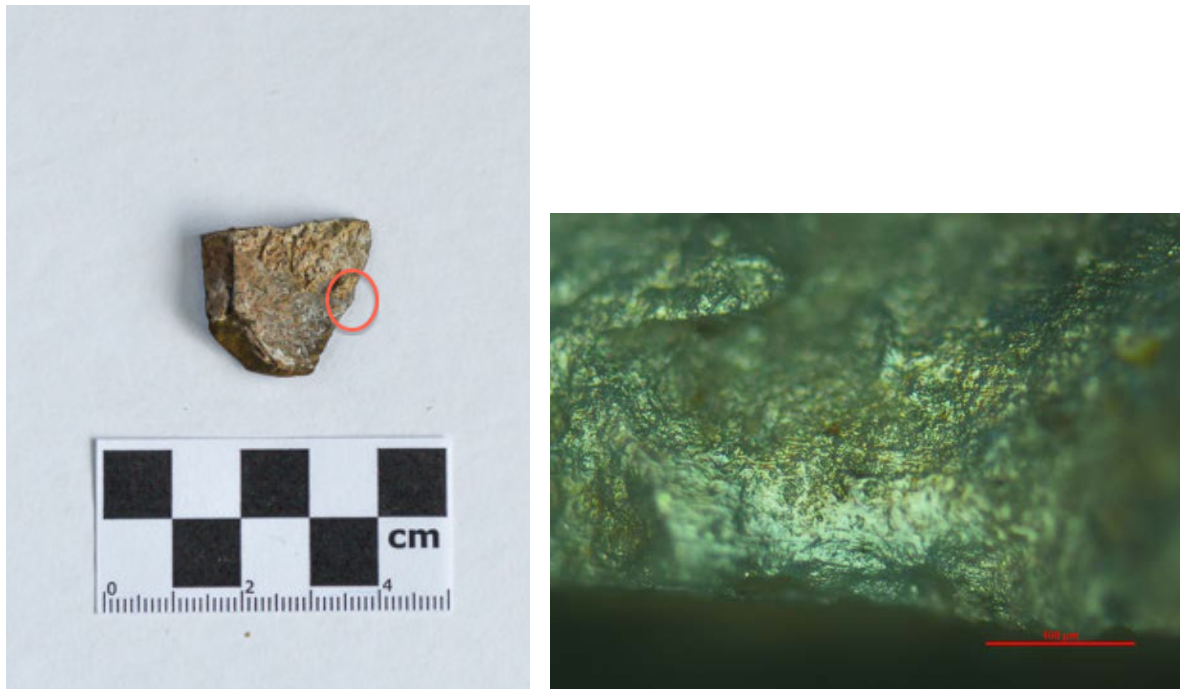


Figure 8.8: Bone polish and longitudinal striations on Unintentionally Modified Flake. (L) Specimen 15023 with circle indicating location of wear. (R) Bone polish and longitudinal striations (magnification 200x).

Another tool (Acc. No. 14686) seems to have been used for multiple purposes. This implement showed continuous microflaking along both the left and right margins. Microflaking was more often feather terminated along the left margin, and step terminated along the right margin, suggesting use in working both hard and soft substances.

Of the five Late B period tools examined, one (Acc. No. 17662) exhibited macroscopic edge damage, but did not reveal any identifiable wear traces. Of the remaining tools, the work actions of only two could be interpreted. Based on the presence of transverse striations, specimen 18003 appears to have been used in a scraping action (Figure 8.9). While the specific nature of the contact material could not be discerned, the presence of significant amounts of edge crushing (micro-step fracturing), as well as an absence of polish development, hint at its use on a dense material. Another specimen (Acc. No. 14602) appears to have been used for multiple purposes,

exhibiting both bifacial microflaking indicating cutting a soft substance and short, multidirectional striations that seem to suggest a whittling action on a harder substance, possibly wood. The work actions of the remaining two tools could not be identified. Specimen 10707 exhibited micro-step fracturing and a lack of polish, suggesting use on a hard substance that removed microflakes faster than polish could develop. The unifacial nature of the microflaking hints at this tool having been used in a transverse motion. The other specimen (Acc. No. 14966) showed primarily fine, feather-terminated microflaking along the used edge, suggestive of use on a softer substance. The edge remained relatively sharp, indicating either use on a very soft substance, or minimal use of the tool.

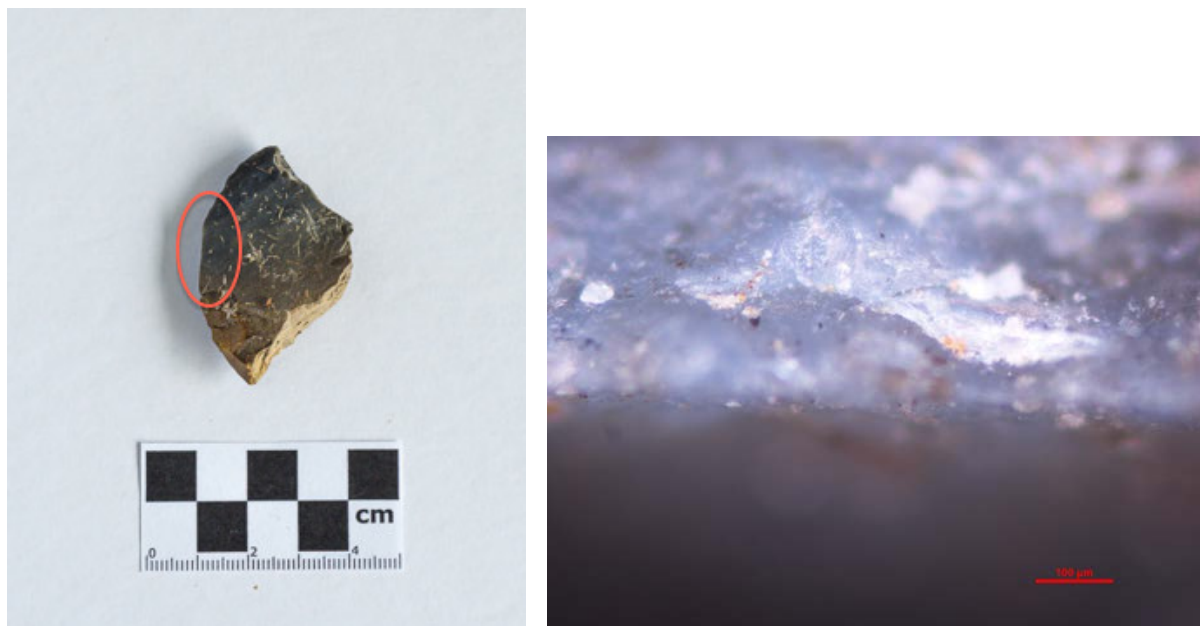


Figure 8.9: Step fracturing on Unintentionally Modified Flake. (L) Specimen 18003 with circle showing location of wear. (R) Sugary texture of successive micro-step fractures along margin (magnification 100x).

Among the Unintentionally Modified Flakes, scraping dry hide, bone/antler, and other hard and unidentified materials was most common in the Early and Mid period samples. By the

Late A period, the functional emphasis had shifted, with more tools being used to cut softer substances and more tools being employed for multiple purposes.

Unintentionally Modified Blades (UBLD)

The Unintentionally Modified Blades are specialized blade flakes selected for use without further purposeful application of edge modification, and they exhibit wear traces as a result of this use. Only ten (n=10) specimens were deemed suitable for microwear analysis: seven (n=7) from the Early period deposits, two (n=2) from the Mid period deposits, and one (n=1) from the Late A period levels. Overall, wear traces on these specimens are not very informative. Many exhibited evidence for use, but their work actions or contact materials could not be interpreted. Others do not appear to have been used at all. Regardless, a variety of activities are represented among those tools that did provide interpretable wear traces.

Among the Early period specimens, one tool (Acc. No. 10350) did not produce any identifiable wear traces, despite some edge damage at the macroscopic level. Microflaking is unpatterned, and no polish was noted. Two others (Acc. Nos. 11570, 18005) exhibited macroscopic wear traces indicative of use, including microflaking and edge rounding, but a lack of polish and striations made it difficult to interpret the origins of this wear. One specimen (Acc. No. 11552) was identified as having been used to cut a soft substance, possibly meat. This tool exhibited patches of bifacial microflaking, indicating a cutting motion, and patches of dull, poorly linked, generic polish on both the dorsal and ventral faces. This polish suggests of contact with a soft material, such as meat. Two of these blade tools (Acc. Nos. 13925, 17131) are interpreted as butchering implements. These specimens exhibited multidirectional striations (transverse, longitudinal, and oblique) as well as a variety of polishes, including bone/antler

(smooth, pitted, very bright), possible fresh hide (bright, greasy polish), and possible meat polish (indistinct, generic weak polish). The last of these Early period tools (Acc. No. 10337) seems to have been used to work an unidentified hard material. Examination of this specimen revealed steep feather and step terminated microflakes and significant edge abrasion in some regions of the edge. No polish was noted.

Both of the Mid period specimens that were examined appear to have been used in a scraping motion, as indicated by the presence of transverse striations. One of these tools (Acc. No. 17115) revealed dry hide polish, while the other (Acc. No. 15270) appears to have been used on an unidentified substance that produced only generic weak polish.

The single Late A specimen examined (Acc. No. 10748) was used to cut a soft substance, but the particular material could not be identified. Continuous, fine microflaking along the dorsal and ventral faces of the working edge are indicative of a cutting motion, but the lack of distinctive polish does not allow the specific contact material to be identified. However, the formation of only weak polish, in association with the fine microflaking is suggestive of a soft material.

The relatively small number of specimens selected for examination from this category means that it is difficult to make broad statements about the nature of the work performed by this category of tools, or the continuity or change noted through time in this class. As with the Unintentionally Modified Flake tools, discussed above, these implements were used in a broad range of tasks, including scraping, cutting, butchering, and working both hard and soft materials. Little patterning is seen in the Early period category, from which most of the implements were examined. With so few specimens considered from other time periods, it is difficult to make any statements regarding change over time. Overall, however, the lack of patterning in functional

traces in this category suggests these tools were expediently used to fulfill a number of task requirements.

Drills (DRL)

Drills are the only category of implement studied here that includes a bifacial variant. Most other bifacial tools from the site represent classes of artifacts, such as Hafted Bifaces, Probable Hafted Bifaces, and Stage Bifaces. Previous research (Driskell 1986; Meeks 1994; Kay 1996; Smallwood 2006) on these tool categories has shown that they were most often used as projectile tips and more general-purpose cutting/butchering implements. Because it was unlikely that inspection of these additional bifacial classes would have provided any novel functional information, the decision was made not to subject them to microwear analysis. In addition to the bifacial drills, a number of unifacial drills were also examined for microwear traces. All of those specimens with identifiable wear traces, in both the bifacial and unifacial categories, appear to have been used to work hard substances, such as bone/antler, and many showed evidence for use in a rotating (drilling) motion.

Bifacial Drills

Nine (n=9) bifacial drills were selected for functional analysis, including three (n=3) from the Early period deposits, five (n=5) from the Mid period, and one (n=1) from the Late A period.

Upon examination, one of the Early period specimens was revealed to have been unused (Acc. No. 17995). Another (Acc. No. 18000) appears to have been utilized, given the presence of micro-crushing on the tip, but I could not interpret the wear traces confidently. The remaining

specimen from this period (Acc. No. 10561) exhibited clear evidence for working bone/antler. The polish noted on this tool is bright and pitted and is accompanied by edge rounding and crushing. Direction of use is more difficult to interpret, as no striations were observed.

Of the 5 Mid period specimens examined, two represent refitted portions of the same tool (Acc. No. 17061, 17062). The proximal portion (Acc. No. 17062) exhibited crushing and edge rounding as well as some generic weak polish on the high points of the microtopography, at the same latitude along both the left and right margins. This wear is interpreted as indicating hafting. The distal portion of this drill (Acc. No. 17061) exhibits rounding and step fracturing near the tip as well as edge rounding of the distal-lateral margins. Proximally from the tip, the margins remained relatively sharp, suggesting only shallow penetration of the implement into the contact material. The remaining two specimens appear to have been used in a rotating motion, as they exhibited bifacial step fracturing and transverse striations on the faces of the tip. One of these tools (Acc. No. 13838) revealed bright, pitted polish on the tip end, suggestive of working bone or antler, while the other (Acc. No. 10884) produced only step fracturing and significant edge rounding with no polish.

The single Late A specimen (Acc. No. 18010) was either unused or used so briefly that no identifiable wear formed.

One specimen from an unknown TCA (Acc. No. 15433; Figure 8.10) revealed significant edge rounding and areas of crushing, including at the tip. Examination with the incident light microscope revealed extremely bright but poorly-linked polish along both faces, especially near the tip. This polish is interpreted as possible bone polish.

Unifacial Drills

Three (n=3) Unifacial Drill specimens were selected for examination: two (n=2) from the Early period, and one (n=1) from the Late A period. Both of the Early period specimens (Acc. Nos. 14556, 17125) were used to work hard substances, as indicated by the presence of significant crushing and edge rounding, but neither produced interpretable polish. Microflaking on these tools was observed on both faces of the left and right tip margins, which is suggestive of a rotational or drilling motion. The single Late A period specimen (Acc. No. 10779) exhibited bifacial crushing on the tip margins and bright, pitted polish, indicating that it likely was used to drill bone/antler.

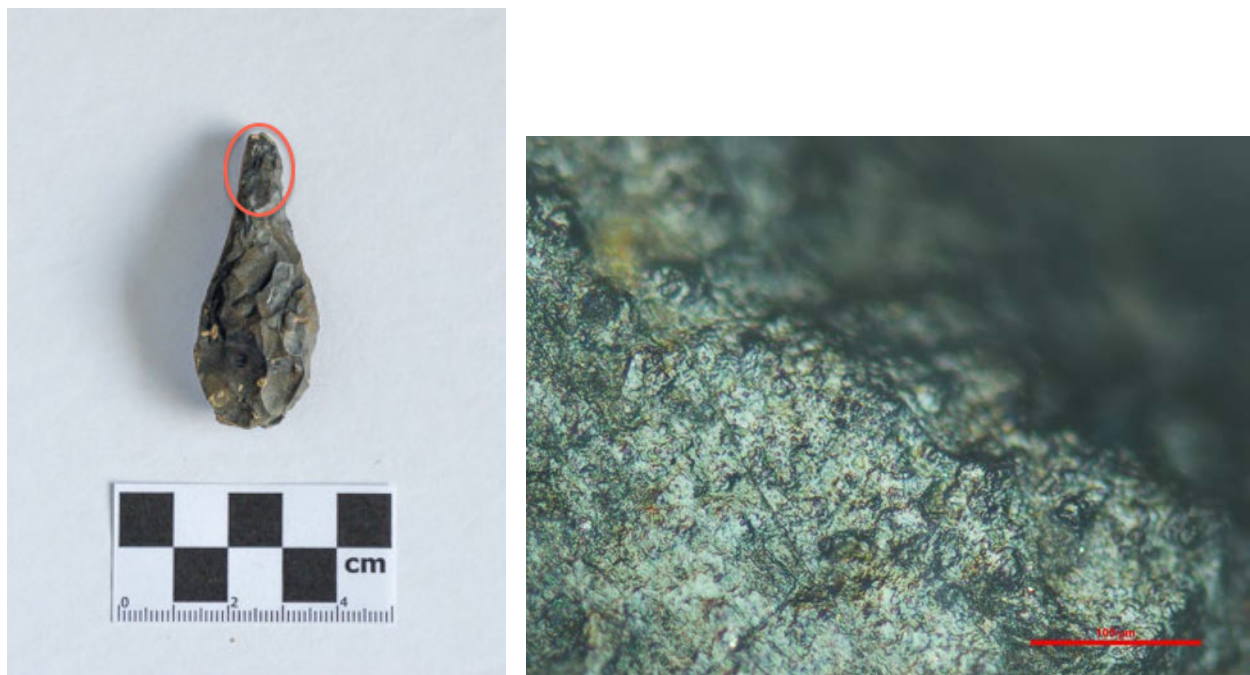


Figure 8.10: Bone polish and striations on Bifacial Drill tip. (L) Specimen 15433 with circle indicating general location of wear traces. (R) Bone polish and striations on tip margin (magnification: 200x).

What is striking about the Drill category is the great consistency in wear patterns, both across time and across sub-classes. While the particular nature of the wear traces could not be

identified with complete certainty for all specimens, consideration of the categories as a whole shows that these tools, some of which were almost certainly hafted, appear to have been used to drill hard substances, particularly bone or antler. The drilling/rotational motion is indicated by the presence of transverse striations and bifacial crushing across the tip. No changes are noted through time in the use of these implements.

CONCLUSION

Analysis of the microwear patterns identified within this sample of tools from Dust Cave has provided insight into several techno-functional issues. First, it has illuminated several general functional trends in the assemblage as a whole and has provided insight into the types of activities being carried out at Dust Cave. Second, it has enabled me to consider changes through time in the activities that were pursued at the site. By extension, it has also allowed me to reflect on those activities that likely were occurring off-site, which is an important consideration when evaluating the production of certain tool forms in advance of use. Finally, it has enabled me to evaluate the validity of my tool class categories and has forced me to reconsider the implied functions of certain type classifications.

General Functional Trends

Among those tools examined here, scraping dry hides appears to have been the most common pursuit. A large number of tools, both formal and informal, exhibited the dull, rough, pitted polish characteristic of working dry hides, and the transverse striations that indicate a scraping motion. Those tools classified initially as End Scrapers were used almost exclusively as hide scraping tools, and were employed in scraping dry hides rather than fresh skins. The

implications of this pattern will be discussed in the concluding chapter, with reference to the representation of deer skeletal elements, patterns suggesting the season of occupation, and the nature of settlement mobility.

Working bone and/or antler appears to have been another common task, based on the wear patterns identified in this study. A variety of tool classes were used in whittling, planing, drilling, and engraving these harder substances. The prevalence of such wear traces is not surprising, given the impressive collection of organic tools recovered from the site (Goldman-Finn and Walker 1994). The bone tool assemblage was dominated by awls, which are puncturing implements formed by grinding down one end of a split bone or splintered bone piece to a smooth, pointed tip. Other awls were produced by “altering only the working ends of small animal or bird bones” (Goldman-Finn and Walker 1994: 108). Antler tines, which are modified to have smoothed tips, represent another common class in the Dust Cave bone/antler tool assemblage. These items likely functioned as perforators or flakers. Needles, which resemble more symmetrical awls with finer tips, were also noted in the assemblage and likely were used in producing clothing, containers, and shelters. Other less commonly recovered bone/antler implements included bipointed projectile tips, a socketed antler point, fishhooks, pins, beads, tubes, and spatulas (Goldman-Finn and Walker 1994). While production of some of these objects appears to have involved grinding and smoothing, it is likely that some of the chipped stone tools (e.g., gravers, whittling implements, draw knives, drills) would have been used in at least some parts of their production. For example, engraving implements may have been used to create the bone splinters that were then modified into awls. Perforating implements may have served to create the holes noted in the eyed needles or the decorative perforated teeth. Whittling tools, draw knives, or spokeshaves may have been used to create the overall tip form of the awls or

projectile points, prior to grinding and smoothing to achieve the desired final form. These chipped stone implements, which appear to have been used in the production of other types of technology, likely reflect activities carried out on-site. The implications of this will be discussed in greater detail in the concluding chapter.

Several implements in the Dust Cave sample were identified as having been used in butchering activities, as they exhibited signs of contact with soft substances (e.g., fresh hides, meat), and bone. Cutting through skin and muscle in order to disarticulate carcasses would almost inevitably have resulted in bone contact, thus accounting for the presence of fresh hide/meat polish, multidirectional striations, and smears of bone polish on these tools. It is likely that some of these implements, perhaps especially the less formal tools on which butchering traces were noted, were used on-site to butcher animals that were hunted in the immediate environs of the cave. Using the plentiful flakes that would have been available at a site where tool production was occurring would have been an efficient use of time and resources. Toolmakers likely produced more formal implements, with great potential for rejuvenation, for use away from the raw material source. Expending effort in the production of such implements would have been less efficient while at the site, where an almost endless supply of sharp flakes could have been mined for specimens suitable for butchery. The implication of this pattern for technological design and use, within the context of subsistence and settlement information from the site, will be considered further in the final chapter.

Other tools within the collection appear to have been used in less particular functions. Many exhibited such minimal wear traces that their precise functions could not be determined. This minimal wear may have been the result of use on particularly soft substances that simply did not cause the types of damage that are more easily recognized, or it may have been a function

of brief, expedient periods of use that did not permit wear patterns to form. Other tools exhibited evidence for use on either hard or soft materials, but the specific worked substances could not be identified. The simplest flake tools served a wide variety of functions, with the classes as a whole showing evidence for use in a variety of work actions and use on a variety of contact materials. The lack of patterning in the wear traces on these tools emphasizes the expedient nature of their selection and use.

Temporal Trends in Tool Function

In addition to general observations about tool function at Dust Cave, the functional analysis has provided insight into temporal trends in tool use. Wear traces from the Early period demonstrate an emphasis on scraping dry hides and producing bone/antler tools. This emphasis persisted in the Mid period, although activities such as butchering, cutting, and scraping of both hard and soft substances were also noted. By the Late period (A and B), hide scraping diminished in importance at the site, and other activities, such as cutting and scraping various substances and butchering animal carcasses seem to have risen to prominence. Multipurpose implements are also relatively common the later occupations. In addition to shifts in the sorts of activities being performed, we also see changes in the representation of certain artifact classes. Fewer formal unifaces were recovered from the later deposits compared to the earlier levels, and there is a relative increase in the prevalence of minimally modified flake tools by the later periods. It should be noted that this shift does not equate to formal unifaces being *replaced* by informal flake tools, as both Intentionally and Unintentionally Modified Flakes and Blades were common in the Paleoindian and Early Archaic levels. The significance of this shift will be considered in the concluding chapter.

Evaluating Type Classifications

Results of the functional analysis have allowed me to evaluate, and in some cases re-evaluate, the type classifications used in this study. The presence of dry hide polish and transverse striations on those tools labeled as End Scrapers has confirmed that they did, indeed, serve as hide scraping tools. Many of the Side Scrapers, however, exhibited evidence for whittling harder substances and cutting a variety of materials. These tools might be better classified as either spokeshaves/draw knives or hand-held knives. Specimens in the remaining Scraper categories did not produce enough interpretable wear traces to allow their functions to be assessed with any degree of confidence. Gravers, recovered primarily from the Early period levels, appear to have been used in incising/engraving hard substances such as bone or antler. It appears that those tools produced on blade flakes were used in functions that mirrored the use of their non-blade counterparts but often exhibited evidence for use in a wider variety of tasks as well. For example, the Blade End Scrapers were applied to scraping dry hides but also appear to have been used for whittling bone/antler. Those implements classified as Intentionally and Unintentionally Modified Flakes/Blades do appear to have been used in an expedient fashion, on a variety of contact materials, and in a variety of work actions. These items exhibited no evidence of repeated resharpening, reworking, or rejuvenation. The lack of internal patterning in wear traces and tool function confirms that these tools were not designed for a particular purpose but instead were drafted into use in a variety of tasks in a more spontaneous manner. Little difference was noted in the range of tasks carried out using the blade and non-blade categories of minimally modified flakes.

In the final chapter, the meanings of these functional patterns are discussed in greater detail. Incorporating the results of the functional and technological analyses into the settlement-

subsistence and environmental frameworks discussed earlier in this volume enables consideration of the ways in which the occupants of Dust Cave were designing, manufacturing, and using their technology in such a way as to facilitate the accomplishment of other cultural goals in response to pressures imposed by the physical environment.

CHAPTER 9: CONCLUSION

This project began with the question of how the rich stone tool assemblage from Dust Cave could be interpreted to demonstrate how forager technology was being organized – both designed and utilized – in order to facilitate the accomplishment of other cultural goals over nearly 7,000 years of site use. This question is particularly relevant in the context of the changing environmental and climatic conditions that existed throughout the occupation. In an attempt to answer this question, I took as a starting point the settlement-subsistence model devised for the region and for the site by Hollenbach (2005) and elaborated by Carmody (2009). These models, in addition to understandings of the environmental changes that occurred, provide a useful framework for interpreting the technological patterns detailed in this volume.

Hollenbach's (2005) model is one in a long line of hunter-gatherer settlement-subsistence models that have been devised and that range from generalized understandings of mobility patterns and food procurement strategies (e.g., Binford's logistical-residential model) to more region-specific variants such as those constructed for parts of the Southeast by Morse (1971; Morse and Goodyear 1973), Gardner (1974, 1977, 1983a, 1983b, 1989), Claggett and Cable (1982), Anderson and Hanson (1988), and Daniel (1998). The more generalized models, such as Binford's (1980), have provided important means for archaeologists to understand how hunter-gatherer populations might be expected to react under certain environmental conditions. Region-specific models, on the other hand, tailor those understandings to the specific contexts noted in study regions or at particular sites and provide frameworks for understanding the specific patterns noted at any given site.

Hollenbach's (2005) is a multifaceted model that includes a general overview for the Middle Tennessee Valley, as well as a model for Dust Cave in particular, which demonstrates how this one site fit into the broader regional context. Her model draws on Central Place Foraging (CPF) theory, a model within Evolutionary Ecology that provides a useful framework for understanding issues of human settlement and mobility. CPF theory suggests that foragers should be expected to transport foodstuffs to a central camp from outlying loci from which particular resources are extracted. Foraging decisions are made that maximize the rate of energy return to that central place. From this perspective, we may hope to understand the range of subsistence decisions that foragers make, including how far to travel in order to procure certain resources, where to locate camps relative to resource patches, and what items to select for consumption when they are encountered. When considering hunter-gatherers, we must account not only for the amount of energy that can be extracted from particular foods and the amount of energy that is expended in their procurement and processing, but also the costs of acquiring, producing, and maintaining the tools required in these pursuits. Central places tend to be located near important resources, including food items and raw materials, especially those that are predictable, abundant, and easily procured. Certain resources, such as plant foods, are generally less risky to procure than are mobile prey species and, for this reason, often form an important component of many hunter-gatherer diets. Plants are predictable in their locations and seasonal availability, and some species may be particularly abundant and nutritious (e.g., oily seeds, nuts).

In Hollenbach's (2005) model of settlement-subsistence during the early occupation of the Middle Tennessee Valley, she suggests that mobility and site locations were organized around the seasonal and spatial availability of predictable and easily acquired gathered resources. These easily gathered resources included species that could have been collected by women,

children, and even more elderly individuals (Hollenbach 2005: 34). Her suggestion, therefore, is that, in the Late Paleoindian and Early Archaic, Dust Cave represented a central place, and that the botanical assemblages provide insight into women's subsistence activities and foraging decisions, as well as those of both younger and older segments of society. Men's activities, on the other hand, are less evident, as these activities appear to have taken place off-site. The lithic data appear to tell the same story and also provide insight into these "male" activities.

In the later periods of occupation at Dust Cave, a shift seems to have occurred from a primarily residential mobility strategy to a more purely logistical form of procurement. Carmody (2009) argues that foraging efficiency seems to have increased by the Middle Archaic. This pattern is reflected in the density of hickory nut remains recovered from the Middle Archaic Dust Cave deposits. Certain plant food options that were lower in calories and more difficult to process were being abandoned in favor of abundant, easily processed, and nutritionally rich hickory nuts. The chipped stone tool assemblage from the Middle Archaic levels reflects such a shift in subsistence priorities, with an abandonment of specialized unifacial implements and standardized blanks in favor of flexible bifacial implements and expedient flake tools. The remainder of this chapter provides a brief review of the technological patterns and considers, in the context of Hollenbach's (2005) and Carmody's (2009) models, how these patterns reflect forager decision-making as a negotiation between subsistence and technological needs. The contributions that the technological patterns make to supporting and refining these earlier models are also discussed.

TECHNOLOGICAL PATTERNS: REVIEW

Late Paleoindian (Early Period)

Occupation of the site during the Late Paleoindian period seems to have been relatively ephemeral, as indicated by the low numbers of artifacts recovered from the earliest levels of the cave. This ephemeral period of occupation may reflect great residential mobility in the early habitation of the Middle Tennessee River valley. Despite covering larger tracts of territory at this time, the Late Paleoindian toolmakers who frequented the cave appear to have focused heavily on the use of locally available, high quality Blue Grey Fort Payne chert. Raw material preferences differed slightly among Late Paleoindian tool classes. While most stage bifaces were produced from BGFP chert and other local raw materials, a single example was manufactured from Bangor chert, which outcrops in north-central Alabama (Meeks 1994; Randall 2001). The preference for BGFP chert extended to the production of Hafted Bifaces as well (Randall 2001). Unifaces were largely produced from BGFP chert, and debitage analysis has revealed that the majority of debris could be attributed to this locally available raw material (Randall 2001). A focus on high-quality raw materials has often been considered a hallmark of Paleoindian technologies (e.g., Goodyear 1979, 1989), reflecting the need for tools that could be curated and stone that could be easily reworked. The strong emphasis on this one stone source may reflect efforts by toolmakers to return to the site during the course of the settlement-subsistence round in order to obtain lithic raw material.

In spite of the relatively low frequency of finds, assemblage diversity was greatest at this time. The Paleoindian toolkit was characterized by an emphasis on flake tools and blade implements, including general Unifaces, Unintentionally Modified Flakes, a variety of Scrapers, and Intentionally Modified Blades. Other classes of tools appeared somewhat less commonly,

including Unintentionally Modified Flakes and Blades. A much smaller number of bifacial tools were recovered, including various Stage Bifaces, Hafted and Probable Hafted Bifaces, and Drills. Perforators, which appear in later toolkits, were absent from these levels, their functions perhaps having been fulfilled instead by the bone awls that were noted in the Paleoindian assemblage (Goldman-Finn and Walker 1994: 110; Walker 1998: 163). Relative to other tool classes from the period, the great importance of blade implements is notable. Many of these tool classes are particularly informative regarding production decisions.

Paleoindian toolmakers at Dust Cave manufactured a variety of bifacial implements, although these tools were recovered less commonly than were flake tools. The sample of bifacial implements included Stage Bifaces, Trimmed Bifaces, Hafted/Probable Hafted Bifaces, and Drills. It is notable that only one Early Stage Biface was attributed to the Late Paleoindian levels. The rarity of bifaces representative of the earliest stages of reduction, in association with a paucity of early stage reduction debris in the debitage sample, may indicate that initial reduction was occurring off-site, likely at the location of toolstone procurement (Meeks 1994: 91). The majority of the bifacial tools from the Late Paleoindian deposits were recovered as fragmentary specimens. The lack of evidence for use-wear on many of these items suggests that they were broken during manufacture. In Randall's (2001) study of the projectile points from Dust Cave, he notes that approximately 30% of the Late Paleoindian Hafted Bifaces from the site were discarded after being broken during use. While these bifacial tools were produced on-site, it appears that most were being transported away from Dust Cave for use elsewhere on the landscape, with Stage and Trimmed Bifaces perhaps functioning as preforms for knives and projectile tips. This pattern coincides with a paucity of deer remains, which suggests that much of the hunting was occurring elsewhere on the landscape.

Examination of the drills revealed patterns suggestive either of breakage during manufacture or of the return of hafted fragments to the site for retooling. Some of these tools were recovered as proximal fragments without refits and may represent proximal portions that were returned to the site for retooling (i.e., reuse of the hafts). Other specimens were represented as distal portions, suggesting use on-site. From my analysis of functional traces, it is clear that many of the tool classes recovered, including several of the drills, were being used to work substances such as bone, antler, and wood in a rotating motion. Given the ample evidence of lithic production at Dust Cave, the use on-site of these other tools in the production of non-lithic technological elements would be likely.

The unifacial tool categories are more informative regarding the spectrum of activities being carried out on the site. Among the flake tools, there is a great emphasis on the use of standardized blades. Many of the End Scrapers were produced from blades, and the use of these standardized blanks is reflected in standardization of tool attributes. Other End Scrapers were manufactured from a variety of other flake types, but even these specimens exhibited similar levels of attribute standardization. Those tools that were created from blade flakes required less post-detachment modification in order to produce the desired characteristics. End Scrapers made from non-blade flakes, on the other hand, tended to be modified more significantly in order to achieve the levels of standardization seen in the blade specimens. This emphasis on standardization of End Scraper proximal measurement suggests a concern with both the re-use of hafts and the potential for easy retooling during intensive periods of use. I suggest that these standardized proximal measurements indicate the use of socket hafts, which encircle the entire proximal portion of the implement and allow relatively rapid retooling. Tools are inserted into the hollow socket, and pressure from expanding lateral margins along with the use of jams or

mastic substances hold the stone bit relatively tightly in the haft (Lancashire 2001: 62). Unlike split shafts, these hafts do not require bindings in order to secure the lithic component.

Many of the End Scraper specimens were recovered in fragmentary condition, with little or no evidence for use and sharp bit margins, suggesting that they were broken either during manufacture or very early in their life histories. In addition to these fragmentary specimens, many examples were recovered in complete or relatively complete condition and with significant evidence for use. These worn implements may have been discarded during the course of toolkit replacement at the site after use elsewhere, or they may represent tools broken during use on the site. My analysis of tool function for the End Scrapers indicates that most were used to scrape dry hides rather than fresh hides, suggesting that hide processing occurred at a time later than initial hunting. The significance of this pattern for our understandings of activity scheduling and site use will be considered in greater detail in my discussion of forager decision-making.

End Scrapers appear to have been designed in such a way as to meet a set of particular technological requirements, especially the potential for successive episodes of rejuvenation, as well as the need to withstand intensive periods of use. They were manufactured from blanks that were long enough to facilitate several resharpening episodes, and, with their highly standardized proximal measurements, seem to have been designed as part of a modular technology that would have enabled easy replacement of broken bits during use. Whether this intensive use occurred on- or off-site will be considered in the following section on scheduling and forager decision-making. As demonstrated by the variability in their lengths upon excavation, the decision to discard any given End Scraper specimen appears to have been made not on the basis of maximum utility extraction but rather in response to the potential for tool failure. The point of potential failure appears to have been identified by tools falling below a certain threshold in their

capacity for rejuvenation. Once the scraper became short enough, and its bit angle became steep enough, it was abandoned in favor of a new, longer tool that could be utilized and rejuvenated over the course of hide scraping without the need for bit replacement (Comstock 2011; Seeman et al. 2013).

Other scraper types, including Ovoid Scrapers and Side Scrapers, showed much less standardization in all attributes than did the End Scrapers. The results of my functional analysis suggest that these tools may have served as cutting implements rather than as scrapers. Little patterning in tool dimensions or other attributes at the time of discard hints that these tools may have been used in a less intensive manner than the End Scrapers and that a concern for resharpening potential and curation may not have been paramount. Examination of the Ovoid Scrapers, however, suggests that this interpretation may not be so simple. These implements received significant post-detachment dorsal modification, an attribute that often signals a concern with curation, as reflected in the greater investment of time and energy in their manufacture and maintenance. It is possible that these formal tools were produced in anticipation of intensive periods of use while stationed at the cave rather than being produced for transport and use off-site. One possible scenario might have these tools being put to use in processing waterfowl that were being hunted in the nearby marshes and karstic uplands during the occupation of the site. The Side Scrapers certainly appear to have been resharpened repeatedly, as they seem to have been discarded upon reaching a particular width-to-thickness threshold, beyond which they may have become too fragile to use.

A collection of minimally modified flake tools was recovered from the site that showed no evidence for resharpening and repeated use. These tools, which included the categories of Intentionally and Unintentionally Modified Flakes and Blades, appear to have been produced and

used on-site in an expedient manner. They were manufactured or selected to fulfill immediate needs without expending time, effort, or additional raw materials. These tools exhibited no significant levels of standardization in any of their attributes. These specimens were recovered in both complete and fragmentary condition, but determining the timing of breakage was difficult if not impossible. With simple flake tools like these, it can be particularly challenging to determine whether the tool was produced from a broken flake, or if it broke during use.

The Late Paleoindian deposits at Dust Cave reveal evidence for the production of a variety of tool types, including Intentionally and Unintentionally Modified flakes. Other tools, including bifaces and formal Unifaces (scrapers, blade tools), appear to have been produced at Dust Cave for use off-site. End Scrapers seem to have been manufactured in such a way as to meet technological requirements during intensive periods of use. These tools were designed with the potential for successive resharpening episodes in mind, were created as part of a modular technology that facilitated easy replacement of broken bits during use, and were replaced at Dust Cave during the course of retooling. The decision to discard several of these tool types (e.g., scrapers) seems to have been made not on the basis of maximum utility extraction, but rather in response to the potential for tool failure, signaled by tools reaching a certain minimum threshold in their potential for rejuvenation. Functional analysis shows an emphasis on scraping dry hides, as well as on manufacturing non-lithic technological components (i.e., working bone, antler, and wood). The significance of these patterns for our interpretations of site use and seasonality will be discussed later in this chapter.

Early Archaic (Mid Period)

Site use appears to have increased in intensity by the beginning of the Early Archaic, as evidenced in part by an increase in the quantity of lithic and subsistence remains recovered. The Early Archaic deposits produced more tools than seen in the Paleoindian levels, and assemblage diversity remained relatively high, especially in the Early Side Notched period. By the later Kirk Stemmed period, diversity had begun to diminish. Many tool types seen in the Late Paleoindian deposits continued to be recovered in the Early Archaic levels, including Mid Stage Bifaces, Trimmed Bifaces, Hafted and Probable Hafted Bifaces, and Drills. Hafted Bifaces were the most commonly recovered tool type in the Early Side Notched deposits. By the Kirk Stemmed period, however, Hafted Bifaces had fallen behind Unintentionally Modified Flakes to become the second most commonly recovered tool type. Throughout the Early Archaic, a decrease in the frequency of flake tools, including Scrapers and other Unifaces, is noted. The Ovoid Scraper, Intentionally Modified Blade, and Unintentionally Modified Blade categories disappear from the Early Archaic assemblage, and only two Gravers were attributed to these levels. Overall, there is a clear shift in emphasis from formal flake tools to biface tools. In addition, less emphasis on standardized blank production was noted, a pattern that is reinforced by the decreased emphasis on blade tools.

Patterns of raw material selection demonstrate that Early Archaic toolmakers continued to show a preference for Blue-Grey Fort Payne chert. However, some differences in raw material use by tool class were noted. By the Early Side Notched, the production of Hafted Bifaces from BGFP chert had increased to 93% over the 80% noted in the previous period, and by the Kirk Stemmed period all bifaces were produced of BGFP (Randall 2001). Despite this emphasis on locally available BGFP chert, Carmody (2009: 151) noted that debitage from the Kirk Stemmed

period flotation samples exhibited diversity in raw material selection. While this pattern might suggest the continued use of relatively large territories, it is important to note that the region surrounding Dust Cave contains a number of other chert sources, including other Fort Payne variants and Tuscaloosa gravels. These may be lower-quality sources than BGFP but are usable nonetheless. Little exotic material was being used at Dust Cave.

With less emphasis on standardized blank production in the Early Archaic, we see correspondingly low levels of artifact standardization, indicating not only that standardized blanks were no longer being produced, but also that tools were not being subjected to as intensive post-detachment modification as they were in the earlier period. The only categories that showed moderate or higher degrees of attribute standardization were the Mid Stage Bifaces and the End Scrapers.

The great paucity of Early Stage bifaces indicates that initial reduction likely was occurring off-site (Randall 2001). Mid Stage bifaces were somewhat more common, but still were not recovered in large numbers and were most often found as fragmentary specimens without evidence for use. These patterns suggest the production and discard of these items on-site. Tool measurements exhibited fairly high levels of standardization, which may be indicative of increased sample size or increased importance of bifaces in the Early Archaic. The greater emphasis on bifaces at this time may reflect a need for a flexible technology, necessitating the production of large numbers bifaces with consistency in their attributes. Such tools could be transformed easily into any of a number of bifacial tool classes. Consistency in the preforms may have allowed easy transformation of these tool blanks into generalized cutting implements or more specialized hafted biface tools.

Among the remaining bifacial tool classes studied (Trimmed Biface I, Trimmed Biface II, Drill), attributes tended to be much less standardized. This pattern likely is related to the fragmentary state in which most of these artifacts were recovered. The Trimmed Bifaces were recovered more often as fragments, with no evidence for use, suggesting that they were broken during manufacture. The Drills, which were recovered primarily as fragmentary specimens, included proximal, medial, and distal portions, suggesting either breakage during manufacture or breakage during use on-site. Wear traces indicating of the use of these tools on hard substances such as bone or antler suggests that these items were being discarded following some period of use. In his study of the Early Side Notched projectile points from Dust Cave, Randall (2001) notes that many specimens were discarded prior to undergoing much resharpening. This observation suggests a lack of concern with raw material conservation at a site where high quality raw materials were easily available.

Turning to the unifacial tool classes, consistency in End Scraper measurements suggests a continued emphasis on easy replacement of these tools during periods of intensive use, likely in socket hafts, as discussed above (see also Lancashire 2001: 62). The overall importance of these items in the toolkit appears to have diminished, though, beginning in the Early Archaic. Most of the End Scrapers were recovered as complete or relatively complete specimens, with evidence for use, suggesting discard of these implements as part of retooling efforts after use off-site or abandonment of tools that had been used on-site. The question remains, though, of whether they represent tools used elsewhere that were returned to Dust Cave or tools that were used on-site. This question is considered further in the following section of this chapter, in which models of forager decision-making and technological organization are discussed. As was the case for the

Paleoindian period End Scrapers, these tools appear to have been discarded upon reaching a particular potential for task failure rather than when they became exhausted.

The remaining unifacial tool classes, including other Scrapers, Gravers, and general Unifaces were recovered primarily in fragmentary condition. Use life and standardization were difficult to assess for many of these tool classes, often because of their fragmentary nature. In general, though, little standardization was noted in the Ovoid and Side Scraper classes, suggesting a) that they were produced for use as hand-held items and b) that toolmakers exhibited little concern for curation in this tool class. Many appear to have been discarded with at least some potential utility remaining. These tools appear to have been used as general implements, with microwear evidence signaling use in butchering activities. Some were well made, with significant investment in post-detachment modification, while others were produced with comparatively minimal investment in additional modification. It is likely that at least some of these tools were produced for use in on-site butchering activities, with effort expended in the production of those implements whose use was anticipated to be somewhat intensive. The Gravers are apt to have been used at the site in the production of organic tool components. These tools received little investment in post-detachment modification, were discarded in various states of repair, and exhibit evidence for incising hard materials such as bone and antler.

A collection of minimally modified flake implements was associated with the Early Archaic levels. Unintentionally Modified Flakes became the most commonly recovered artifact from the later Early Archaic Kirk Stemmed levels. Randall (2001, 2003) notes that several cores were recovered from these levels that appear to have been used in the production of expedient flakes. Both the Intentionally and Unintentionally Modified Flakes were recovered most often as fragmentary specimens, but it is difficult to assess whether these tools were broken during use, or

produced on flake fragments. Lack of evidence for repeated resharpening or rejuvenation of the minimally modified flaks (Intentionally and Unintentionally Modified Flakes) hints at their use as expedient implements to fulfill immediate needs on-site. The prevalence of these expedient tools suggests a shift in technological needs at the time, as curated implements other than bifaces seem to have begun to fall out of favor.

Overall, the Early Archaic toolkit revealed an increased emphasis on bifaces and a decreased focus on formal flake tools. A heavier reliance on simple modified flake tools in relation to other tool types was noted. These simple tools likely were used in carrying out tasks on-site, rather than being prepared for use off-site. The Early Archaic assemblage seems to bear witness to an impending shift in site use and in the particular range of activities being carried out at the cave. Rather than the emphasis on gearing-up for intensive periods of hunting and processing, we begin to see a greater concern with gathering activities occurring during the Early Archaic. Technological activities did continue, though, although the emphasis began to shift toward the production of a more flexible bifacial technology rather than the highly specialized, formal unifaces noted in the Paleoindian period. With the exception of the small number of End Scrapers recovered, most tool classes from the Early Archaic deposits began to show greater degrees of variability in their measurements and attributes. The End Scrapers continued to be produced with relatively standardized attributes, likely to facilitate easy retooling during intensive periods of processing. These implements were discarded upon reaching the potential for task failure, rather than upon reaching their maximum utility. They were abandoned before they broke and before they were reduced sufficiently that tool replacement would have had to occur at a critical moment during use. Other tool classes, including certain other unifaces and minimally modified flake implements, appear to have been used and discarded much more

expediently and likely represent activities that were carried out on the site rather than away from the cave.

Analysis of the functional wear traces on these tools revealed a continued emphasis on dry hide scraping and the production of bone/antler tools. In addition to these patterns, though, more evidence was noted for cutting and butchering activities, as well as for the scraping of both hard and soft substances.

Middle Archaic (Late Period)

As a whole, the Middle Archaic deposits produced the greatest number of tools by far, although frequencies for the Late A (Eva/Morrow Mountain) and Late B (Benton) periods on their own appear lower. This apparent incongruity is the result of difficulties in assigning many tools to a particular period, which forced me to group them into a general “Late Period” category. Trends in lithic density are important to consider, in addition to raw tool counts. Analysis of debitage from flotation samples from the Eva/Morrow Mountain deposits revealed a decrease in lithic density, a trend reversed by the Benton phase (Carmody 2009: 149). The debitage revealed, in particular, a diminishing emphasis on tool maintenance and late stage production at the site. Carmody (2009: 149) notes a corresponding decrease in faunal remains recovered from these flotation samples, which, in association with a decrease in the numbers of scrapers recovered from these zones, indicates that hunting had become a less significant activity at or near the site.

While artifact density seems to have diminished overall, the lithic assemblage reveals an interesting shift toward abandonment of the wide variety of tool types employed in earlier periods and an adoption of a more focused bifacial toolkit. Levels of tool kit diversity in the

Eva/Morrow Mountain period were similar to those seen in the later Early Archaic deposits, revealing a significant decrease in diversity from the Late Paleoindian and Early Side Notched periods. By the Benton period, toolkit diversity had diminished substantially as the technological inventory began to reflect shifting use of the site toward a specialized activity locus, rather than a generalized residential site. The Eva/Morrow Mountain sample revealed an increase in the representation of bifacial tools compared to a decrease in the frequency of more formal unifaces and minimally modified flake tools. Perforators (unifacial drills) appeared in the tool kit for the first time, and the number of Intentionally Modified Flake tools increased, while the frequency of Unintentionally Modified Flakes decreased. By the Benton period, Hafted Bifaces and Trimmed Biface II specimens comprised more than 70% of the toolkit. Overall, the assemblage revealed a continued increase in the emphasis on bifacial technology, especially in relation to the lower frequency of unifacial implements. No formal unifaces were recovered from the Benton levels, and the flake tool sample from this time comprised only minimally modified flake tools (Intentionally and Unintentionally Modified Flakes).

Despite a decrease in lithic density in the Middle Archaic levels, there is still evidence for tool production and use on-site. The Late Period levels reveal a great emphasis on the number of bifaces produced over later periods. Many of these tools were recovered as fragmentary implements and lack evidence for use. It appears that most were broken during manufacture, rather than representing tools broken during use. Production emphasis in flake tools appeared to shift to the use of biface flakes, with little or no use of standardized blade flakes. This shifting emphasis corresponds to the increased use of bifacial tools, as toolmakers likely were scavenging the by-products of biface manufacture for the production of flake tools.

A consideration of tool standardization revealed much greater variability in all tool classes except for the small number of End Scrapers recovered in the Eva/Morrow Mountain period. These minimally modified tools continued to exhibit fairly great levels of standardization.

Among the small sample of unifacial specimens recovered from these later levels, fragmentary specimens included segments from all portions of the tools (proximal, medial, distal) suggesting that these artifacts were broken either during manufacture or use on-site. Of the Intentionally and Unintentionally Modified Flake tools recovered, almost all were complete or relatively complete, and no evidence for resharpening was noted. These patterns suggest expedient on-site tool use and discard.

An assessment of tool functions from the Late Period (A and B) levels revealed that hide scraping had decreased in importance. Instead, the chipped stone tool assemblage revealed evidence for cutting and scraping of other hard and soft substances, much of which is interpreted as evidence for animal butchery.

Technological Patterns: Summary

Patterns in the density of lithic materials recovered from the Early Period to the Late Period may suggest shifts either in the intensity of site use or in the range of activities being carried out at the site and elsewhere. Debitage analysis (Carmody 2009: 149-150; Hollenbach 2005: 262; Meeks 1994: 91-93) revealed a spike in the Early Side Notched, indicating a great emphasis on late-stage tool production and maintenance at this time, followed by a dramatic drop in debitage recovery. While this may indicate a decreasing concern with technological activities, it is more apt to indicate a shift in site use after the Early Archaic. Through time, the

technological assemblage reveals a decrease in tool diversity, an abandonment of blade technology, and a diminishing reliance on formal unifaces. In contrast, the frequency of biface use increases dramatically. By the later periods, it appears that minimally modified flake implements had replaced the functional position of more formal unifaces.

With an abandonment of blade production, an increase in biface use, and an increase in the use of minimally modified, expedient flake tools, levels of artifact standardization also decreased through time.

Tool use life varied by tool type and by period. In the Early and Mid Periods, several tool classes appear to have been discarded prior to task failure rather than at the point of complete exhaustion. It seems that the need for usable tools during intensive periods of use (e.g., bulk hide processing, butchering) outweighed concerns over raw material economy during the earlier occupations. A desire to conserve raw materials may have been of even less concern given the relative ease of toolstone availability in the immediate environs of the site.

As a whole, these patterns appear to represent a shift from the use of Dust Cave as a central place within a residential mobility pattern in the earlier period, to a specialized activity locus in a logistical mobility strategy in the later periods of occupation. Another possibility is that the site continued to be used as a retooling station, but the range of activities for which toolmakers were gearing up changed. These options are not mutually exclusive, and we may in fact be seeing evidence of both changes occurring. Occupation of the site in the Paleoindian period appears to have been relatively ephemeral, although it is likely that the site was used repeatedly, albeit over brief, episodic intervals. By the Early Archaic, it seems site use was becoming more intensive, with nut processing becoming of primary concern toward the end of the Early Archaic and into the Middle Archaic. By the Middle Archaic, we see yet another shift,

as the site appears to have become used partially as a mortuary locale (Hogue 1994; Sherwood et al. 2004).

SUBSISTENCE AND TECHNOLOGICAL ORGANIZATION MODELS

The technological patterns summarized above may be considered in association with the settlement-subsistence models developed by Hollenbach (2005) and Carmody (2009) in order to elaborate and refine our understandings of changing hunter-gatherer scheduling and decision-making throughout the use of Dust Cave. While assessing the position of Dust Cave in the organizational strategies of these foragers, it is important to recall that this site is located at the intersection of several biomes from which a variety of subsistence resources could be procured at different times throughout the year. In addition, the site is located within close proximity to a source of high-quality lithic raw material. Foragers typically are forced to make scheduling decisions that seek a compromise between the particular distribution of subsistence resources, and the location of spatially restricted lithic sources. This conflict between the need for food and the need for tools that are used to acquire that food is a fundamental structuring principle in much of hunter-gatherer settlement, subsistence, and technological organization strategies. At Dust Cave, this particular conflict was lessened dramatically, which had particular sorts of impacts on the organization of cultural activities, as will be considered below.

Late Paleoindian

Hollenbach's (2005) subsistence model suggests no seasonally exclusive use of the site during the Late Paleoindian Period, but rather repeated episodes of use throughout the year in order to take advantage of shifts in seasonal resource availability. Some of these periods of site

use likely were brief and ephemeral, while others may have been more intense. The ephemeral nature of Late Paleoindian site use, as evidenced by the relative paucity of artifacts and subsistence remains from these early levels, is good evidence against year-round occupation of the site. Low numbers and limited diversity of feature types in the Late Paleoindian deposits might also hint at the ephemeral nature of the occupation, although Homsey (2004: 210-214) cautions that this pattern may result from post-depositional processes (e.g., fluvial events) rather than reflecting the range or intensity of activities occurring at the site. Regardless, Dust Cave appears to have functioned as an important central place from which a range of foraging activities could be scheduled and organized throughout the year.

Hollenbach (2005) posits shifts in subsistence pursuits throughout the year, depending on the seasonal availability of resources and changes in animal behavior patterns. These shifts impacted forager organizational strategies and the use of Dust Cave and would also have influenced technological decisions. During the spring, she suggests that foragers would have focused on river settings, where spawning fish, migratory waterfowl, and game species that were attracted to spring shoots and leaves could have been targeted. Foragers may even have exploited these weedy greens themselves. Deer tend to be lean by the spring, having lived in large part off their fat reserves through the winter months. Targeting deer at this time would, therefore, have provided fewer calories, perhaps encouraging hunters to focus on alternative food sources such as waterfowl. By summer, foragers may have exploited fruits that were ripening in close proximity to the site. Hunters may also have targeted game at this time, perhaps at greater distances from the site, as deer tend to disperse during the summer months. By fall, turkeys would have begun to flock, and deer, which are in prime condition after having stored fat for the winter, would have aggregated for the rut. Foragers in the region may, therefore, have focused on

slope and upland habitats at this time of year, when these resources could be targeted. In the winter, logistical hunting parties may have continued to track game that gathered in the spruce yards of the Late Pleistocene. Little use of plants is postulated for the winter season, with the exception of opportunistic use of lingering fruits and seeds. Stone raw material procurement likely was embedded in these subsistence pursuits as a means of offsetting the relatively high costs of transporting stone (Hollenbach 2005: 366). The location of Dust Cave at the intersection of river, marsh, slope, and upland habitats, and its proximity to high-quality stone sources, would have made this site an ideal location for a central place, from which a wide variety of resources could be exploited logistically. Driskell (personal communication, 2016) has suggested that the Paleoindian use of the site may well have extended past the drip line, but that evidence of the true extent of site use at this time has since been washed away. It is probable that the Paleoindian presence may have been more significant than demonstrated by excavations within the cave, but we may never be able to confirm this possibility.

While it is likely that Dust Cave was used or occupied throughout the year during the Late Paleoindian period, continuous occupation is an unlikely scenario. In addition to the relative paucity of artifacts and subsistence remains compared to later periods, feature data from the Late Paleoindian occupations suggests that site use likely was relatively ephemeral. Features from these early levels included hearths and refuse from hearth cleaning. Bone appears to have been deposited near the back wall of the cave, where dampness would have precluded occupation. With the exception of some prepared surfaces near the central portion of the entrance chamber, few specialized features were noted.

In assessing what the technological data reveal about and contribute to our understandings of Late Paleoindian site use and scheduling at Dust Cave, three patterns are of

particular importance. First, the great density of bird remains, especially waterfowl, is notable in comparison to the relative paucity of deer remains. Second, there is a great emphasis on tool manufacture and maintenance at the site. And, third, the Late Paleoindian toolkit revealed a great focus on formal unifaces and blade implements.

It is clear that Blue Grey Fort Payne chert was being procured from sources close to the site, and it is likely that this procurement was embedded in the performance of other tasks. Given the proximity of the site to a high-quality lithic raw material source and to a variety of subsistence resources, it is likely that foragers were drawn to this site not for any single reason but because of the richness and variety of available resources, a level of variety that is reflected in the archaeological traces recovered from Dust Cave.

Tools made from Blue Grey Fort Payne comprised the majority of the Late Paleoindian toolkit, but subtle variations are noted in raw material selection according to tool class. When raw material preferences are compared across categories, it appears that the Late Paleoindian occupants of Dust Cave exhibited a preference for high-quality Blue Grey Fort Payne chert for the production of their hafted bifaces in particular. It appears, as Hollenbach (2005: 101) suggests, that these toolmakers were more willing to use materials other than high quality Blue Grey Fort Payne in the production of tool classes other than hafted bifaces and that these other tools may have been discarded at the site in the course of retooling.

These patterns in raw material use suggest several behaviors. First, with the presence of at least some non-local raw materials in the sample, it is tempting to assume that Late Paleoindian settlement patterns may have been wide-ranging (Randall 2001) or that these populations may have maintained extensive social networks. However, many of these non-local

materials are available in small quantities in the local environment, and so may not provide a good measure of mobility.

Second, the paucity of non-local materials in the debitage sample suggests the those tools made from exotic materials that were recovered at Dust Cave likely were transported as finished or partially finished formal tools rather than being produced from transported cores. These implements may have been curated over the course of transport and maintained through continued use at the site, but production on-site of tools from non-local materials was not occurring.

Third, the low numbers of unifacial implements produced from non-local raw materials indicates that these items either were not being transported over long distances or were being discarded along the way. Only one of the 156 unifaces studied by Randall (2001) was produced from a material other than BGFP, a pattern that has been confirmed in my own work. While some of the unifacial tools from Dust Cave were highly formal (e.g., End Scrapers), they did not appear to have been curated in the sense of being cared for and transported over extended periods. Instead, it appears that these tools may have been produced and used on sites that lay in close proximity to raw material sources. I will return to the question of their great formality in spite of an apparent lack of transport in my discussion below.

Finally, a difference is noted in the positions of bifaces and unifaces in the organization of the technology. Unhafted bifaces, which are often cited as being a particularly flexible form of technology (e.g., Kelly 1988), were being transported over greater distances than were unifaces. While Paleoindian tool users clearly had great need for specialized unifaces, such implements may have been less useful during periods of mobility, as they were more cumbersome and less flexible. By this, I mean that a tool user would have had to carry a wider selection of specialized

tools to fulfill the potentially great range of anticipated and unanticipated needs that emerged during the course of settlement mobility. While each of those specialized tools would likely have been more efficient at completing any particular task, the flexible nature of the bifacial technology may have allowed a variety of tasks to be accomplished relatively well, while simultaneously reducing transport costs.

Debitage analysis by Meeks (1994: 91-93), as well as observations by Hollenbach (2005: 262) and Carmody (2009: 149-150) as part of their flotation analyses, have shown that tool manufacture and maintenance were occurring on-site, as evidenced by the recovery of small flakes. However, the low numbers of cores, early stage reduction debris, and early stage preforms (for example Early Stage Bifaces and Mid Stage Bifaces) suggests that initial processing and reduction of lithic material occurred near the source rather than at the cave (Meeks 1994: 91-96). While blade flakes were common in the Late Paleoindian assemblage, no blade cores were recovered from the earliest levels at the site. Several blade cores were recovered from locations in Coffee Slough, though (Meeks 1994: 101), emphasizing the focus on reducing waste and increasing returns to the central place. Later-stage preforms (Trimmed Biface I, II) likely were produced on-site, as many of these specimens were discarded in fragmentary states with little evidence for use. This pattern suggests breakage during manufacture, rather than during the course of use. These observations imply that late stage stone tool manufacture and maintenance were occurring on-site, while earlier stage reduction was occurring elsewhere. Reduction of raw materials at the site of procurement provides a means to reduce waste and thus minimize transport costs, which are of primary concern to mobile foragers. Pre-tested and partially reduced pieces could have been returned to Dust Cave for further reduction into a variety of bifacial and unifacial tool types.

As well as the production of stone tools, it appears that other technological components were also being manufactured at the site. The only gravers recovered from Dust Cave were excavated from the Late Paleoindian levels. Microscopic analysis of these implements revealed that they were used in incising hard materials such as bone and antler. A small collection of drills was also recovered, with some specimens exhibiting no evidence for use. One of these specimens, however, was used to drill a hard substance, likely bone. The presence of these tools suggests the production on-site of organic tools, such as the four awls and single perforated tooth recovered from the Late Paleoindian zone. Organic tool components, such as tool handles and shafts, likely were also produced using these implements.

In addition to manufacturing and maintenance, a variety of other technological activities appear to have been carried out at Dust Cave. While little consideration was given in this study to the categories of Hafted and Probable Hafted Bifaces, Meeks (1994: 96-98) presents evidence for these tools having been used as knives and projectile points, indicating that hunting and related activities were of importance. However, the paucity of deer remains on the site from the Late Paleoindian levels suggests staged processing of these animals. It is likely, given seasonal patterns of deer behavior, that the major period of hunting and processing was in the late fall and early winter. During this season, deer are calorically rich, having put on fat for the upcoming lean winter months, and are more active and less cautious, making them easier targets for hunting. Following the autumn mating season, deer likely yarded or aggregated in the spruce forests that covered the uplands during the Late Pleistocene (Hollenbach 2005: 80, 2009: 95). It is likely that these fall and winter months provided the best hunting for the occupants of Dust Cave. It is during this season that deer are more likely to be taken at a distance from the camp, as their caloric values are high (Hollenbach 2005: 78-83). If transport costs and waste could be

reduced by field dressing and partial processing of the carcasses, then returns may have been even higher. Skinning and preliminary butchering, as well as discard of less valuable elements, would have ensured a return to the consumers of the portions of greatest utility from these animals. Walker (1998: 144-147) has noted that deer element representation in all periods at the site indicates the discard at Dust Cave of the least valuable portions (e.g., crania, limbs, feet), a pattern that reinforces the notion of processing for the purpose of increasing returns. This suggests that preliminary processing and waste reduction was occurring at Dust Cave, with valuable elements being transported away from the site.

It is likely, therefore, that the Dust Cave population occupied or frequented the cave during the fall and early winter in order to take advantage of the bounty of resources, both subsistence and technological, that were available during this season. I propose that occupation may have been relatively intensive during the fall months, either as frequent, repeated habitation episodes, or as periods of prolonged site use. Waterfowl, which comprised a significant portion of the Dust Cave faunal assemblage (see Walker 1998: 106-113), may have been targeted earlier in the fall and would have served as an excellent food source while populations also made forays to exploit nuts, lingering fruits, and weedy seeds. At this time, toolmakers may also have spent time gearing up their toolkits for the anticipated intensive period of deer hunting that would occur slightly later in the season.

The argument can be made that, under certain conditions, stone tool production is best scheduled during periods of foraging down-time, when toolmakers are not engaged in other time-intensive activities. This pattern is seen in riskier, unpredictable environments, or under conditions of time stress on the accomplishment of other activities. Scheduling tool production in such a way ensures that time is not diverted from these other tasks and that toolkits are prepared

for when they are needed. While a period of hunting waterfowl and gathering plant food resources might not seem to qualify as down-time, it is important to recall that human foraging populations tend to divide their work along gender and age lines (Kelly 1995). As Hollenbach (2005: 23-30, 360-362) discusses, women and children may have played a role in the gathering of plant foods and hunting of smaller animals. It is quite possible that one segment of the Dust Cave population may have engaged in subsistence pursuits at this time, taking advantage of the rich and varied food resources available, while another segment procured raw materials and replenished the toolkits. If the interpretation of hunting as a male pursuit is correct (Hollenbach 2005: 23-30, 360-362; Hawkes 1996), then it would be reasonable to assume that men would also have been responsible for maintaining their hunting kits. This interpretation of the season of occupation and site use during the Late Paleoindian reinforces the view of Dust Cave as a Central Place: a base camp where every day residential activities occurred and from which logistical forays for toolstone, plant foods, and animal resources could be organized.

After the major period of deer hunting in the autumn, I suggest that this group of foragers may have returned to or continued to occupy the cave in order to process hides, and possibly to replenish toolkits once again. This suggestion receives some support from other categories of tools recovered from the Late Paleoindian levels.

The Late Paleoindian deposits produced 39 End Scrapers and probable fragments. This sample includes 28 firmly identified End Scrapers, Blade End Scrapers, and End Scraper fragments from Zones T, U, and S2, as well as 9 Type III Unifaces, which I have interpreted as likely representing proximal fragments of dorsally flaked End Scrapers. The presence of both complete/relatively complete and fragmentary specimens suggests that these items may have been produced and/or used on-site. While it is possible that toolmakers were gearing up to

engage in hide scraping elsewhere, discard patterns are more suggestive of the use of these tools on-site.

In a study conducted on a collection of Early Archaic End Scrapers from the Nettling site in Ontario (McMillan 2003), I noted patterns suggestive of use of these tools at locations removed from the site and the discard of those tools as part of retooling efforts. End Scrapers found on this site could be divided according to the location of stone procurement: exotic vs. local. Those specimens produced from local materials were fragmentary or were discarded as a result of manufacturing errors. These tools were long, sharp, and exhibited no evidence for use. Those tools produced from exotic materials, which presumably had been transported and used over the course of this forager population's annual settlement round, were discarded *en masse* at the site and had been used to exhaustion. Many of the exotic specimens had been resharpened down to nubs and exhibited steep, worn, rounded working edges. It appears that nearly every last ounce of utility had been extracted from the specimens that had been transported over long distances and used while away from the raw material source.

This is not the pattern we see in the Dust Cave sample. Instead, among the complete and relatively complete specimens, there is microwear evidence for these tools having been used, but they were discarded with various degrees of utility remaining. Many were long enough that they could have continued to be resharpened for some time, while others appeared more heavily used. The sample also included fragments that may have been broken during use and fragments of tools broken during manufacture. I suggest, then, that the Dust Cave toolmakers were producing and using End Scrapers on-site, when hunters returned from their logistical forays with skins and carcasses to process.

This possibility is strengthened by my observation that these tools were being used in scraping *dry* hides. In dry hide scraping, “the skin is stretched out tightly, dried completely, and the grain is shaved off with a very sharp tool” (Edholm and Wilder 2001: 18). This is contrasted against wet hide scraping, in which the wet skin is laid over a hard surface such as a log, and the grain is essentially pushed off using a tool with a longer and comparatively duller edge. While wet-scraping tends to produce a finished product that is described by modern skinners as being “bouncier” and “livelier” and takes less time initially than does dry-scraping, dry-scraped hides tend to be easier to dress, as they absorb brain better during the tanning phase, and they dry more rapidly in the softening phase than do wet hides (Edholm and Wilder 2001).

While dry hide scraping does take longer, this extra time may have been of little concern if hunters returned to Dust Cave after major episodes of deer hunting. Hides could be stretched and dried at the site while other activities were carried out in the shelter of the cave. These activities may have included processing of the carcasses, production and maintenance of hunting and other tools, and gathering of food resources (e.g., lingering plant products, mussels, etc.). Given the fact that these foragers appear to have exploited resources available earlier in the fall (nuts, seeds, waterfowl), there may have been a reserve of foods available for consumption while post-hunting processing of meat and hides occurred, and while toolmakers replenished their now depleted and worn hunting kits.

One particularly notable feature of the Late Paleoindian End Scraper sample is the great emphasis on attribute standardization, especially of the proximal measurements. Stone tool components designed in this way likely facilitated easy bit replacement during the course of tool use, and are seen as reflecting an emphasis on reliability in tool design (Bleed 1986; Nelson 1991: 66). Reliable tool designs have been argued to represent the concerns of toolmakers and

users who occupy environments in which subsistence choices are unpredictable or in which activities occur in brief, intense episodes when game types and their locations are predictable. Standardization (e.g., of haft elements, as seen in the End Scrapers) serves to allow redundancy in technological components, as back-ups can be created for easy bit replacement during these intensive periods of use.

If, as argued in this volume, the Dust Cave hunters were returning to the site with carcasses requiring further processing, this period of hide preparation may have been a relatively intensive one. It is quite likely that individuals who were scraping hides may have anticipated using several scrapers over the course of preparing skins. As discussed elsewhere in this volume, hafts typically are viewed as the more valuable piece of technology, having required more time and effort to produce than the stone bits, which could have been produced in bulk for easy replacement during use. Producing standardized haft measurements on the stone tools may have facilitated easy replacement during these intensive periods of use, especially if these tools were being used in socket hafts. Socket hafts are produced by hollowing out the end of the shaft so that the haft material encircles the proximal portion of the stone component. The tool may be wedged into this socket relatively securely, and may be further secured by the addition of a mastic substance or with the use of a shim (Lancashire 2001: 62). Worn or broken bits could have been removed easily and replaced with fresh stone components, rather than requiring the additional work of wrapping the stone bit in order to secure it, as is required when using a split shaft.

The production of standardized End Scrapers for easy bit replacement was accomplished through modification of both standardized and unstandardized blanks. Those produced on more standardized blades received little post-detachment modification, yet their measurements were

consistent with those produced on unstandardized blanks that received significantly more post-detachment modification. The creation of relatively consistent measurements on tools produced from both standardized and unstandardized blanks provides support for the suggestion that haft elements were being reused. While it is argued here that many of these scrapers may have been used on-site, standardization of these tools would have been an important concern even for tools that were produced for use off-site. Replacement bits could have been manufactured *en masse* in order to facilitate easy replacement in curated hafts while under time and raw material constraints.

Given that both minimally modified and dorsally modified End Scrapers exhibited similar degrees of proximal measurement standardization, it is apparent that consistency in measurements can be achieved in a variety of ways. Why, then would toolmakers elect to produce standardized blade flakes for the production of these tools, given the great effort and skill required to create them? The focus on standardized blank production that is apparent in the End Scraper sample may reflect an effort to produce blanks with sufficient length to allow a maximum number of resharpening episodes, which (Comstock 2011; Seeman et al. 2013) has argued is the most important consideration in End Scraper production and discard. These long, narrow blanks could also have been created for transport, being curated and easily transformed into a variety of other tool types while away from the raw material source. The flexibility of this blank type may have made them especially attractive to mobile Late Paleoindian populations.

In addition to the End Scrapers, several other tool classes were produced and utilized by the Late Paleoindian inhabitants of Dust Cave, and all of these classes provide important insight into the nature of activities occurring at and away from the site and the technological decisions being made by toolmakers. Hafted Bifaces likely were produced for use off-site and transport

away from the cave. These tools, with their generalized forms that could have been adapted to meet a variety of functional needs, represent an emphasis on versatility in the design of a maintainable toolkit (Bleed 1986: 740; Hayden et al. 1996: 13; Nelson 1991: 70-71).

Maintainability is typically emphasized in circumstances under which portability is a concern. Portability would have been a primary concern during periods of high mobility, when settlement mobility would have imposed transportation constraints, when there were continuous technological needs, and when conditions of use were unpredictable.

On-site, there is ample evidence for the use of a range of simple and often expedient flake tools, which may have fulfilled similar functions on-site as the bifaces served while away from the site. Those implements initially identified as Side Scrapers revealed microwear traces suggestive of cutting soft materials, rather than scraping hides. These tools, which perhaps are more accurately classified as knives, are more formal than some of the simple flake tools that also appear to have been used in a similar capacity. With a greater potential for multiple resharpening episodes, these more formal tools may have been produced for use during more intensive periods of processing.

In addition to these more formal implements, excavations produced a sizable collection of simple flake and blade tools that likely were used expediently. These Intentionally and Unintentionally Modified Flake and Blade implements exhibited no evidence for resharpening or maintenance. They likely were produced with little forethought or were scavenged from production debris, utilized briefly in the performance of tasks on-site, and discarded almost immediately. Randall (2001) notes that BGFP chert cores for the production of expedient flakes were recovered from the Late Paleoindian levels but that they were found in significantly lower numbers than those seen in later deposits. These classes of tools, which generally indicate

domestic activities occurring on a site, were recovered in significant enough numbers to suggest at least some relatively substantial periods of site use. Microwear analysis on these implements was largely inconclusive, given the brief episodes of use they endured, but those that did show microwear traces appear to have been used primarily as general cutting implements. More formal bifacial implements that were used in similar tasks, such as cutting and butchering, were being produced on site but appear to have been manufactured in anticipation of transport and use elsewhere. Using simple flake tools to fulfill the same needs would have allowed tool users to accomplish these tasks without exhausting the formal implements that required greater investment of time and energy to produce.

Technological traces from the Late Paleoindian levels seem to support the suggestion that Dust Cave was occupied in the fall. It is unlikely, though, that fall represented the only period of site use. Migratory waterfowl would have returned in the spring, when spawning fish such as sucker would also have been available. As Hollenbach (2005: 78-83) suggests, mammal species likely would have been drawn to the marshy and river habitats to drink and to feed on tender spring shoots. Deer may have been relatively lean at this time and, therefore, less nutritionally attractive, but if they could be taken close to the site, then the reduction in transport costs may have compensated for the decline in caloric value. Foragers may also have exploited some of the spring greens (Hollenbach 2005: 256). These sorts of subsistence activities would have required a different set of tools than those employed for intensive hunting episodes in the fall. Baskets or bags may have been more characteristic of the spring toolkit. During the summer, foragers likely exploited ripening fruits, examples of which were recovered in the botanical assemblage. Other resources, such as deer, may have been a little more dispersed at this time, and migratory waterfowl would not yet have made their semi-annual appearance. Occupation of the site during

this season may, therefore, have been more fleeting and ephemeral than in the fall. During any of these other seasons, foragers are apt to have taken advantage of the easily accessed stone raw materials in order to replenish exhausted toolkits or to prepare for upcoming needs. In fact, these periods of relative subsistence “down-time” may have provided the perfect opportunity to engage in gearing up, as limited time would not have been diverted from intensive subsistence pursuits.

Overall, it seems that the technology of the Late Paleoindian period reflected at least some subsistence unpredictability, higher degrees of settlement mobility, and time stress in certain activities. I propose that technological concerns may have been a significant factor in drawing Late Paleoindian populations to Dust Cave. Toolmakers who used the site, which was located in close proximity to a high-quality chert source, could have replenished their toolkits and produced standardized blanks (blades) that could be produced rapidly and in relatively large quantities, and that could be modified easily into a variety of specialized tool types. In addition to the production of lithic technology on-site, it is clear that non-lithic technological components were also being produced on-site. Tools such as gravers and drills exhibited evidence for use in working bone, antler, or wood, and likely functioned in the production of handles, hafts, and other organic tool components. While occupying the site for the purpose of toolkit replenishment, the Dust Cave population took advantage of seasonally available subsistence resources, including migratory waterfowl. This food source would have provided ample nutrition, perhaps while requiring less time to procure and process than other animal resources, leaving ample time for technological activities.

Early Archaic

Early Archaic site use seems to have followed a similar pattern to that interpreted for the Late Paleoindian period. The site seems to have functioned as a residential base camp where domestic and technological activities occurred. This interpretation is based on the nature of the subsistence remains, the nature of the lithic assemblage, the number and diversity of features, the separation of living and refuse areas, and the presence of large storage pits (Carmody 2004: 40; Homsey 2004: 246).

The large quantities of nuts recovered at the site (Carmody 2009; Hollenbach 2005, 2009), as well as the identification of a deer frontal bone with antlers attached, which was recovered from the Early Side Notched levels (Walker 1998: 150), suggest an emphasis on site use during the autumn.

While it is likely that this mobile population returned to Dust Cave at other times of the year as well, the most intensive period of use may have occurred during autumn to coincide with mast production. Warming and drying trends were set in motion at the end of the Younger Dryas, creating ideal conditions in the region for the expansion of mast species, which included acorn and hickory. With these changes in climate and forest structure, nut-bearing species became particularly desirable subsistence targets that could be exploited with relative ease on a seasonal basis. The use of nuts in the Early Archaic increased from the preceding Late Paleoindian period and overtook the exploitation of other plant resources such as *Chenopodium* and other weedy seeds. While acorn use peaked in the Early Side Notched period, hickory became the dominant nut species seen in the Kirk Stemmed deposits. Mast species likely were monitored throughout the seasons, during the course of the settlement-subsistence round, and were exploited as they ripened in autumn. These nuts, which are high in calories and nutritious fats, may have been

processed and stored for consumption during leaner times of the year, thus dramatically reducing subsistence unpredictability. The use of fruits also spiked in the Early Archaic, pointing to a summer/early fall occupation as well.

The inhabitants of the site appear to have been targeting forest resources more consistently, exploiting deer, squirrel, and turkey throughout the Early Archaic. Waterfowl continued to be targeted, but in much lower frequencies than those seen in the Late Paleoindian assemblage. Other aquatic resources, including fish and mussels, became much more frequent in the faunal sample of the Early Archaic. This shift likely reflects, in part, the changes in river dynamics that accompanied broader climatic trends following the end of the Younger Dryas. Differences in settlement-subsistence organization may also have contributed to this changing focus.

In association with the subsistence data from the site, examination of the feature assemblage from the Early Archaic levels provides additional insight into site use at the time. As was the case with the Late Paleoindian levels, Early Side-Notched deposits appear to have suffered from post-depositional alterations as a result of fluvial activity, which may have altered the representation of features (Homsey 2004). Regardless, the Early Side-Notched levels revealed charcoal and ash concentrations and stringers as well as charcoal pits that may have served as expedient hearths for cooking fish. Prepared clay surfaces may also have been used as griddles for cooking fish or platforms for roasting nuts. Another dumpsite for refuse was noted at the back of the cave, where similar Late Paleoindian deposits had been recorded.

By the Kirk Stemmed period, in the latter portion of the Early Archaic, features had increased in frequency and diversity. The Kirk Stemmed feature assemblage included charcoal and ash pits, various hearth types, prepared clay surfaces, and a rock pit that may have

functioned as an earth oven. Clustering of features within the cave suggests a concern with conserving space. Homsey (2004: 210-214) cautions that the apparent increase in the number and diversity of features in the Kirk Stemmed deposits may be a result of post-depositional processes (e.g., fluvial events) that reduced the number of features recorded from the earlier Early Side-Notched deposits, making the Kirk Stemmed deposits appear more feature-rich. Overall, the subsistence and feature data reveal an increasing use of fish and nuts throughout the Early Archaic as well as a greater emphasis on hunting.

This apparent subsistence shift is further supported by examination of the technological data. Perhaps the most notable trend in the Early Archaic lithic assemblage is the dramatic increase in Hafted Biface frequency. At the beginning of the Early Archaic (Early Side-Notched), Hafted Bifaces had become the most commonly recovered chipped stone tool class on the site. By the Kirk Stemmed period, bifaces had slipped behind Unintentionally Modified Flakes to become the second most common tool class. This dramatic increase in biface representation over the Late Paleoindian period suggests a greater emphasis on hunting mammals. The emphasis on bifaces, which can fulfill a variety of technological needs, may also reflect the choice of a versatile, maintainable technology. Bleed (1986: 740), Hayden et al. (1996: 13), and Nelson (1991: 70-71) argue that this design consideration may characterize groups living under portability constraints, continuous technological needs, and unpredictable scheduling. It is perhaps important to recall here that the Early Side Notched period, at the opening of the Early Archaic, overlapped with the Preboreal Oscillation, a secondary climate reversal that created environmental instability for a period. Populations at this time may have relied on high residential mobility to compensate for this unpredictability.

Blue-Grey Fort Payne chert continued to be the preferred raw material source for Early Archaic toolmakers, a preference that intensified in the Kirk Stemmed period. This focus on local materials left particular traces in the Early Archaic archaeological record at Dust Cave. Throughout the Early Archaic, we see nearly exclusive use of BGFP chert in most tool classes, and in the sample of debitage. By the Kirk Stemmed period, all Hafted Bifaces were being produced from BGFP (Randall 2003). This focus on a particular, locally available raw material, and the observation that most of the Early Side Notched Hafted Bifaces were being discarded prior to undergoing significant resharpening, suggests that raw material conservation may have been of little concern to the Dust Cave toolmakers. This interpretation is reasonable, given the close proximity and easy access to the raw material source. This shift toward near-exclusive use of locally available BGFP chert in the production of Hafted Bifaces by the earliest part of the Early Archaic reinforces the suggestion that Early Archaic populations were becoming less residentially mobile than were the Late Paleoindian groups. The question remains of whether this pattern represents increasing territorial circumscription and decreased mobility or simply an increase in site use redundancy.

Hollenbach (2005: 100-101) notes that the great emphasis on high-quality BGFP chert in the Early Archaic is significant, given the common assumption that the production of “technically-demanding Late Paleoindian hafted bifaces” would be more easily accomplished by relying on high-quality raw materials. Elsewhere in North America, Archaic populations do not tend to exhibit the same narrow focus on high quality raw materials, as many began to use more locally available sources upon settling into diverse regions (Anderson 1996: 46). It may be that this pattern of raw material use at Dust Cave indicates a social component to the selection (Hollenbach 2005: 101). Another simple explanation, however, may be that, as regional

populations became larger and more geographically constrained, the local group that used Dust Cave simply had the good fortune to have settled into an area that housed a high-quality lithic raw material source.

Examination of the debitage from flotation samples (Carmody 2009: 145-150) revealed that the density of lithic debitage increased dramatically in the Early Side Notched but dropped back to Late Paleoindian levels in the Kirk Stemmed period in association with a great increase in the representation of nutshell. Various researchers have considered debitage patterns from the site (e.g., Carmody 2009; Hollenbach 2005; Meeks 1994) and have noted patterns suggestive of a decrease in the importance of technological activities at Dust Cave, but this apparent trend may not be quite so straightforward. While it may reflect a decreased emphasis on production, the decrease in debitage may also be a function of the increased importance of expedient flake implements in the Early Archaic toolkit. It is true that little early stage production debris was recovered from these levels and that early stage bifaces were few in number. Other bifacial tools, however, do appear to have been manufactured or reduced on-site, including some Trimmed Bifaces that showed no evidence for use and appear to have been discarded after breakage during manufacture. As discussed above, bifaces became a particularly important facet of the technology throughout the Early Archaic occupations, as did expedient flake tools. Cores for the production of expedient flake implements were recovered from the Early Archaic levels in significantly greater numbers than seen in the Paleoindian zones. While many of these tools appear to have been produced from dedicated expedient cores (Randall 2001), it is likely that others were being created from the by-products of tool manufacture. By the Kirk Stemmed period, the frequency of Unintentionally Modified Flakes overshadowed bifaces, formal flake tools, and Intentionally Modified Flakes. To keep pace with the increased demand for expedient

technology, toolmakers may have responded by scavenging suitable blanks from amongst the production debris created during the manufacture of other tool classes. The frequency of flake tools produced from biface flakes speaks to this possibility and reflects the increasing emphasis on biface tool production at this time. As Unintentionally Modified Flakes became the most commonly recovered tool type at Dust Cave by the end of the Early Archaic, scavenging production debris may have altered the representation of certain classes of debitage in these later Early Archaic levels.

At the same time that the use of simple flake tools (Intentionally and Unintentionally Modified Flakes) was increasing, the earlier emphasis on specialized flake tools began to wane. End Scrapers continued to be recovered from the various Early Archaic levels, but their quantities were greatly reduced compared to the number of these tools excavated from the Late Paleoindian zones. This pattern may seem confounding, given that the faunal data indicate that deer hunting continued to be of importance throughout the Early Archaic. By extension, then, hide scraping likely would have remained a significant pursuit as well. The low frequencies of End Scrapers may indicate that hide scraping was occurring off-site, a pattern that may signal the beginnings of an organizational shift. The End Scrapers recovered from the Early Archaic levels may represent tools discarded at the site during the course of retooling. With the exception of a small number Type 3 Uniface fragments interpreted as proximal fragments of dorsally flaked End Scrapers, all End Scraper specimens were recovered in complete or relatively complete condition. These tools appear to have been discarded upon reaching a particular minimum length threshold. It is suggested that the proximal fragments and at least some of the used and/or exhausted specimens may represent tools that were returned to the site along with their hafts for toolkit replenishment.

Other unifacial tools were becoming less common in the toolkit, a pattern that foreshadows the Middle Archaic trend toward the use of flexible rather than specialized technologies, including bifaces and minimally modified flake tools. These technological changes reflect the shifting nature of activities occurring on the site. Unifaces were much less common in the Kirk Stemmed deposits than in the Early Side Notched, coinciding with an increasing emphasis on the exploitation of plant foods in the latter portion of the Early Archaic. The toolkit required for targeting and processing mast resources would necessarily have been very different from one used in hunting and may have included items such as baskets and bags for collecting, nutting and grinding stones for processing, and prepared clay platforms for roasting. Other domestic activities that were occurring at the site during the period of nut procurement could have been accomplished easily with the use of simple flake tools (Intentionally and Unintentionally Modified Flakes), the production and selection of which required little investment of resources, leaving sufficient time for engaging in intensive collection and processing activities.

A notable difference from the preceding Late Paleoindian period is the significant reduction in the use of blade flakes for tool production. The use of blades as a potentially very flexible type of blank that could be transformed into a variety of specialized flake tools was discussed earlier. As the highly flexible bifacial technology began to assume prominence in the toolkit and specialized unifaces became progressively less important, the need for highly specialized blanks from which to create these unifacial implements would have decreased.

In addition to chipped stone tools, other classes of technology were in use and indicate the range of on-site activities being carried out during the Early Archaic. Reinforcing the importance of nut processing at the site, the Kirk Stemmed deposits produced a total of five

nutting stones (Randall 2003). Various bone tools were recovered from the site, including awls, needles, fishhooks, projectile points, and various decorative items (beads, perforated teeth). The Kirk Stemmed period bone tool assemblage was larger and more diverse than that recovered from the Early Side Notched level. The presence of needles, which would have been used in tailoring, suggests that hide scraping likely continued to be important despite a reduction in the number of End Scrapers.

It is clear that, throughout the Early Archaic and especially by the Kirk Stemmed period, the subsistence emphasis had shifted heavily toward the use of plants, a pattern that had significant implications for technological behaviors. This focus on plant resources required a toolkit that differed from a hunting kit, one that seems to have included ground stone implements and prepared clay surfaces and likely would have incorporated baskets or bags for collection. This shifting emphasis became especially apparent by the end of the Early Archaic, as less debitage was recovered from the Kirk Stemmed zone than from the Early Side Notched (Carmody 2009: 100). It is clear that manufacturing and maintenance activities continued, as evidenced by the recovery of cores for expedient flake production and some bifaces that seem to have been broken and discarded prior to use, but the importance of these technological activities seems to have declined relative to other pursuits by the Kirk Stemmed period. The reduced focus on maintenance may be related to the nearly exclusive reliance on locally available raw materials for tool production, more extended or more frequent stays at the site, and a consequent reduction in the need to conserve raw materials. Randall (2002: Ch. 6) noted the discard of ESN Hafted Bifaces prior to significant resharpening, a behavior that would have resulted in the production on-site of significantly less maintenance debris, especially given the increasingly prominent role of bifaces in the toolkit.

The nature of subsistence pursuits and technological behaviors in the Early Archaic may also provide insight into the division of labor at this time. While little change is noted in subsistence, technology, and site use between the Late Paleoindian and Early Side Notched periods, a shift occurs in the Kirk Stemmed period. At this time, the increased focus on nuts, the reduced frequency of deer remains, and paucity of hide scraping tools indicate the beginnings of a shift in site use from a more multi-purpose residential camp in the Early Archaic to a logistically exploited locale by the Middle Archaic. Hollenbach (2005: 23-30, 360-362) has argued that the collection of plant foods may have been the domain of women, while men may have been primarily responsible for hunting. If this is the case, then the activities we see occurring on-site during the Kirk Stemmed period may be especially representative of “women’s work.” With the paucity of hunting/processing tools and deer remains from the Kirk Stemmed, men’s work may be relatively less visible. Men may have been engaged in replenishing their toolkits while women gathered plant foods in the fall. Deer are in prime condition during the fall and are attracted to mast resources at this time, suggesting that men and women may have divided their activities during this season. Upon returning to the site, the Dust Cave inhabitants would have engaged in roasting and processing nuts for storage and consumption and may also have targeted nearby mussel shoals. Nuts mature over the period of several months, but the window for harvesting is relatively short, especially once competition for these resources by other animals and molds is considered (Hollenbach 2005: 201). This means that the period of nut procurement by humans would have been short and intensive, leaving little time for the performance of additional activities. This observation may account partly for the lack of End Scrapers on-site, as these tools were used for dry hide scraping, which requires prolonged

periods to accomplish. The occupants of Dust Cave may have been too busy during the nut harvest to engage in hunting and processing activities while nut harvesting occurred.

It seems that the Early Archaic period at Dust Cave represents a time of cultural transition. The beginning of this period produced evidence for a persistence of many of the Late Paleoindian patterns, including the possibility of high residential mobility, perhaps in response to the unpredictability created by the brief Preboreal Oscillation. Throughout the remainder of the Early Archaic period, though, subtle subsistence and technological shifts begin to appear. Overall, it appears that the primarily residential mobility strategy interpreted from the Late Paleoindian data continued in the Early Side-Notched period. It is likely that these foragers continued to occupy the site on a somewhat recurrent basis, using Dust Cave as a central place for the staging of their subsistence and technological pursuits. The diverse technology common in the Late Paleoindian period persisted in the Early Side Notched and reflected the varied subsistence resources that continued to be targeted. The varied technological assemblage provides a snapshot of the broad range of domestic activities that would have been carried out at this residential site, including lithic and organic tool manufacture, hide preparation, and processing of botanical and faunal resources. The picture these data paint is one of residential mobility, with a camp being established at this site in order to take advantage of a range of resources. A continued emphasis on locally available raw materials, along with evidence for discard of certain bifaces prior to undergoing significant resharpening, suggests a lack of concern with curation. This pattern may indicate territorial circumscription, increased familiarity with the landscape, and more redundant site use.

By the Kirk Stemmed period, however, settlement seems to have begun shifting toward a more logistical strategy, with Dust Cave being used more frequently for the exploitation of mast

resources. The faunal and botanical assemblage revealed more focused use of mammals and nuts, and the lithic assemblage revealed a less diverse toolkit. Tool use at Dust Cave during the Kirk Stemmed period placed much more emphasis on bifaces and the use of expedient flake tools, while specialized unifaces had nearly disappeared from the assemblage. This pattern suggests that Dust Cave began to be used for very specific purposes, including processing nuts and gearing up for logistical hunting forays. It seems that subsistence scheduling was becoming more predictable and that the occupants of the cave were becoming more familiar with the landscape and its available resources. The reduction in technological diversity suggests a population that was becoming highly organized and focused in its subsistence pursuits and that could predict precisely what tools would be needed at any given time. Task groups were being provisioned with appropriate toolkits prior to embarking on logistical forays. At this time, Dust Cave may have functioned as a nut processing station and a locale for replenishing hunting kits that would be used elsewhere in the region. Targeting specific locations on the landscape for particular subsistence and technological purposes indicates increasing familiarity with resource distributions and periodicity, as well as continued territorial reduction.

The Early Archaic, therefore, seems to occupy an intermediary position between Late Paleoindian cultural patterns and the beginnings of a transition to patterns that intensified in the Middle Archaic (e.g., an increasing use of plant foods, small mammals, fish, reptiles, and an overall greater emphasis on forest species). By the end of the Early Archaic, these trends had intensified greatly, ushering in an era of more highly specialized site use and the exploitation of more predictable resources in the more stable landscape and climate of the Middle Archaic.

Middle Archaic

In his analysis of Middle Archaic subsistence patterns, Carmody (2009) argued that subsistence remains from Dust Cave indicated greatly increased foraging efficiency. The Middle Archaic inhabitants of the site were concentrating on plant resources and had begun to focus in particular on species that yielded high returns for relatively minimal effort. In comparison to the broad range of plants exploited in the earlier periods, the diversity of plant foods gathered by the end of the Middle Archaic had diminished significantly. This pattern may be related in part to decreased use of the site as headroom in the cave became reduced (Carmody 2009: 129).

At this time, foragers ceased targeting edible seeds to the same degree as seen in the earlier periods, representing an abandonment of foods that provided low returns and incurred high processing costs. The density of hickory remains recovered from the Middle Archaic levels indicates that hickory nuts had become the preferred food source during the later occupations. Harder-to-process nut taxa such as acorns, black walnuts, hazelnut, and fruits had decreased in representation. Occupants of the cave appear to have been making great use of open/edge environments that expanded during the warmer and drier conditions of the Hypsithermal.

The use of terrestrial and mammalian species increases in relation to the exploitation of aquatic species and non-mammalian taxa. Deer and squirrel were targeted heavily, while the use of birds diminished. Fish exploitation was noted, but in relatively low frequencies.

Feature data, presented by Homsey (2004: 247-248), reflect these increasingly focused dietary choices. The number of features increased in the Middle Archaic, but the variety of feature types diminished. Processing pits were common, and, in association with nutting stones and the density of hickory nutshell recovered from the site, suggested intensive and focused use of the site for nut processing. The number and diversity of features decreased in the Benton

period, likely reflecting decreased headroom and a resultant decrease in the intensity of site use. Based on her analysis of the feature assemblage, Homsey (2004: 247-249) interpreted the Middle Archaic data as indicating that Dust Cave served as a logistical site for processing nuts that were then transported to remote base camps.

All of the subsistence data from the Middle Archaic period, as well as the feature data, point to an increase in foraging efficiency. The lithic data support this interpretation, revealing technological choices that would have facilitated this increase in subsistence efficiency.

The lithic data from the Middle Archaic period paint an intriguing picture of behavioral changes in the latter periods of site use. Overall, the Dust Cave deposits reveal a decrease in lithics through time, including tools and debitage. Carmody (2009: 150) notes an exception to this pattern in the Benton period, though. Increases in the amounts of lithic materials during the latest period of site use has been interpreted as the result of “occupants’ participation in the Benton Interaction Sphere (Meeks 1998), an exchange network involved in the communal production of stone tools for long-distance trade” (Carmody 2010: 18). Given that the preceding Eva/Morrow Mountain period lasted nearly 1,000 years longer than the Benton period, this comparatively greater density of lithics is especially significant. Environmental changes during the Hypsithermal, which coincides with the period of the Middle Archaic, appear to have promoted population increases, which in turn resulted in territorial circumscription and reduced mobility across the Southeast. With groups being forced into closer proximity with one another and having less freedom to move around the landscape, we see the emergence of “long distance exchange and trade networks as a means to acquire ornaments, raw materials, and other materials sought as symbols of high status” (Carmody 2010: 6). Another explanation for this pattern, though, may lie in the apparent mortuary function of Dust Cave during the Eva/Morrow

Mountain phase. Use of the site for stone tool production may have declined in importance relative to use of the site as a burial locale.

Debitage analyses revealed a continued focus on Blue-Grey Fort Payne chert, reinforcing more local use of the landscape. While little evidence was seen in thedebitage sample for late-stage manufacture or maintenance of stone tools, manufacturing activities clearly continued at or near the site. Occupants of Dust Cave were producing Hafted Bifaces and Trimmed Biface preforms, which collectively make up more than 70% of the Benton period chipped stone tool assemblage. These “preforms” (Trimmed Biface II) would have been easily transported implements with the flexibility to be transformed into Hafted Bifaces or any of a number of other bifacial implements. Hafted Bifaces likely functioned in a flexible capacity as projectile tips and hafted knives. The frequent recovery of deer remains from the site, in association with these technological patterns, reinforces the importance of hunting at this time. The reduction in late stagedebitage does not, therefore, indicate a lack of emphasis on bifacial production. This pattern may be the result of either a change in activity scheduling or a reduced emphasis on maintenance. It is possible that tools were “roughed-out” at or near Dust Cave, then transported elsewhere for final production. Alternatively, toolmakers may have become less concerned with maintaining and curating tools as an outcome of redundant site use. In other words, if toolmakers knew they would be returning with some frequency to the raw material source, then material conservation through successive maintenance episodes may not have been a priority. Either of these possibilities may be explained with reference to increased territorial circumscription as a result of increasing population density in the Middle Tennessee river valley, which promoted redundancy in site use and a logistical settlement pattern.

Despite the emphasis on hunting, the number of End Scrapers recovered decreased dramatically by the Middle Archaic. This paucity of End Scrapers, despite an abundance of deer remains, is somewhat confounding, as hide processing would have continued to be a concern to these foragers. One possibility to explain this pattern is that, as the Holocene climate changed and stabilized and forager populations settled in to the landscape more confidently, they identified other high quality raw material sources. These could be exploited throughout the year, as part of an increasingly logistical settlement strategy, resulting in End Scrapers being used and/or discarded at sites removed from Dust Cave. However, the consistent use of Blue-Grey Fort Payne chert throughout the history of occupation, regardless of settlement organization, does not lend strong support to this argument. Another possibility is that dry hide scraping, which seems to have been accomplished with the use of End Scrapers in the Late Paleoindian and Early Side Notched periods, may have been replaced in later periods with the practice of wet hide scraping, a practice that requires a different tool form. The lithic assemblage from these later levels produced few specialized unifaces, and microwear analysis revealed little evidence to suggest that any wet hide scraping occurred on site. A final possibility to explain the disappearance of End Scrapers is that changes in activity organization and scheduling meant that hide scraping was now occurring off-site. This possibility is strengthened by other data that suggest increasingly logistical organization in the settlement-subsistence round. Hides may have been transported to a different location for processing. Walker's (1998) analysis of bone element representation at the site, which revealed the discard of less useful portions (limbs, feet, and heads), indicates that carcasses were being "brought back to the site, processed and discarded in the cave" (Walker 1998: 147). It seems likely that the best portions of meat, as well as the hides,

were being removed from this site and returned to the central base camp for further processing and consumption.

Overall, the subsistence and technological data indicate that Middle Archaic foragers were engaging in a much more segmented activity structure, exploiting both food resources and lithic raw materials logistically. With the occupants of Dust Cave engaging in such strictly scheduled subsistence pursuits within the logistical settlement system, toolmakers likely were able to predict more accurately their technological needs, including knowing what implements would be required at what times and in what quantities and knowing when and where they could acquire stone raw materials for toolkit replenishment. Logistical mobility strategies have been interpreted as a reaction to a reduction in the capacity for residential mobility (Binford 1980: 17; Kelly 1999: 53), likely brought about in this case by environmental change, population growth, territorial circumscription, and continued adjustments to the landscape and its available resources. Following Ames (1981), Carmody (2009: 153) notes “if a logistical style organization pattern emerges in a region,...over time these logistical systems should become more complex, bounded, and distinct.” Such behavior will produce more redundant archaeological records, which is precisely the pattern that we see at Dust Cave.

SUBSISTENCE AND TECHNOLOGICAL ORGANIZATION:

UNDERSTANDING FORAGER DECISION-MAKING

Humans are cultural animals, but it is important to recall that we are still animals and, as such, we are forced to meet challenges posed by the natural environment. We must consider how to locate and secure food and water, what dietary choices to make, how to cope with seasonal climatic fluctuations, etc. We meet many of these challenges through the design of our cultural

systems, including how we organize our settlement and subsistence practices, and how we design and organize our technologies. In studies of prehistoric hunter-gatherers, a consideration of subsistence and technological patterns allows us to approach an understanding of the ways in which foragers confronted the challenges posed by both their natural and social environments. Lithic artifacts often represent the only traces of these prehistoric adaptive responses and so provide an important window on the decisions that were made in the creation, modification, and utilization of cultural elements intended to meet these adaptive challenges. When coupled with well-preserved faunal and botanical datasets like those recovered from Dust Cave, our interpretations of forager decision-making strategies are strengthened. In this section, I discuss the decisions that were made by the occupants of Dust Cave regarding their settlement-subsistence organization and the organization of their technological systems as they met the challenges posed by shifting Pleistocene-Holocene environments.

It is tempting to think of differences in Paleoindian and Archaic settlement strategies as falling into the residential-logistical dichotomy proposed by Binford (1980). Previous site interpretations used this dichotomy, especially in emphasizing the clearly logistical use of the site as a nut-processing station in the Middle Archaic (e.g., Carmody 2009). The apparently more ephemeral nature of the occupations in the Late Paleoindian and Early Archaic periods might seem to indicate a more highly residential strategy, but the technological data seem to paint a slightly more nuanced picture of settlement-subsistence organization than a simple residential-logistical split.

Based on Binford's (1980) model of hunter-gatherer settlement organization, Kuhn (1989) proposed a series of technological correlates of residential and logistical strategies, indicating that scheduling of technological activities would appear different in residential

systems and logistical systems. Residential mobility is typically seen in environmental contexts in which resources are thinly but evenly distributed across the landscape (Binford 1980) and in which food procurement is essentially a constant activity. Under such subsistence-based time constraints, tools can only be replaced during brief, daily periods of “down-time,” meaning that toolkit maintenance is a fairly continuous task. In such systems, we should expect to see tools being retained to the point of complete exhaustion, with the decision to discard being based on absolute or immediate utility.

Logistical organization, on the other hand, is seen in environmental contexts in which resource distribution is patchier. Spatial and temporal incongruities in resource availability result in extended periods of “down time” between procurement episodes, allowing toolkit repair and maintenance when subsistence tasks are of less importance. From a technological perspective, logistical organization entails periods of intense tool use that produce one of two possible organizational responses: the production of complex toolkits that are highly reliable, or the replacement of tools before they wear out. This latter option reduces the severity of risk in task performance by creating a more reliable technology and ensuring that the potential for tool failure is minimized (Eerkens 1998; Kuhn 1989; Torrence 1989b).

Analyses of the faunal (Walker 1998), paleoethnobotanical (Carmody 2009; Hollenbach 2005), and feature (Homsey 2004) assemblages have been interpreted as indicating a shift from generally higher degrees of residential mobility in the Late Paleoindian and Early Archaic, to a more purely logistical use of the site by the Middle Archaic. To a degree, my technological analyses confirm these patterns. However, it seems that organizational tactics in the earlier periods may be more complex, making it impossible to classify the settlement-subsistence

strategy as simply “residential.” Hollenbach (2005) has discussed this possibility, noting that logistical hunting parties may have pursued game into the uplands during the colder months.

Analysis of the technological patterns from the earliest levels at Dust Cave certainly suggests some incongruous patterns, if we interpret the Paleoindian and Early Archaic habitation as representing a purely residential settlement strategy. In certain tool classes, such as the End Scrapers and Hafted Bifaces, we do not see evidence for discard of tools following extraction of maximum utility, as is predicted for technological systems employed by residentially mobile foragers. Instead, the patterns suggest discard of tools prior to failure, matching the predictions for a logistical strategy. At the same time, though, we do see evidence for the production of tools that likely were removed from the site for use throughout the settlement round. Based on these patterns, I suggest that early inhabitants of the region may have moved camps more frequently, indicating a degree of residential mobility, but that, during the occupation of sites like Dust Cave, they may have exploited certain resources in a logistical manner. By the Middle Archaic, however, there is much clearer evidence for logistical use of the landscape, and for the role of Dust Cave as a specialized extraction site.

The cultural shifts noted at Dust Cave are interpreted as representing an increase in foraging efficiency in the context of environmental change, territorial circumscription, and increasing familiarity with the landscape. Subsistence, settlement, and technological strategies at all stages appear to have been organized to facilitate the most efficient use of available resources.

Examination of the subsistence data reveals the use of a broad range of foods in the Late Paleoindian period and a progressive decrease in diet breadth throughout the occupation. The varied dietary selections apparent in the Late Paleoindian assemblage may reflect the greater subsistence unpredictability and less subsistence productivity that likely characterized the mixed

oak-hickory-pine forests of the Younger Dryas cold reversal (Delcourt and Delcourt 1987; Hollenbach 2005: 50-58). A higher degree of residential mobility may have allowed inhabitants of the Middle Tennessee River Valley to cope with this unpredictability by moving to locations wherever resources were available and to target a wide range of foods located within close proximity to their residential camps. Once a given location was exhausted, this mobile population could pack up and move to the next available patch, presumably exploiting an equally varied range of subsistence options. This pattern seems to have persisted relatively unchanged through the Early Side Notched period. By the end of the Early Archaic and into the succeeding Middle Archaic, the climate warmed, the environment stabilized, and populations began to expand, forcing local groups to settle into the landscape and target resources in a more purely logistical manner. This shift is reflected in the Dust Cave data, which indicate a change in site use from a residential base camp to a specialized nut processing station. By the end of the occupation sequence, the great subsistence emphasis had turned to the use of resources that provided great return for comparatively little investment.

This apparent organizational shift was both prompted and facilitated by changes in the environment as the climate warmed. This environmental shift altered the structure of forests, allowed river systems to stabilize, and resulted in a drying of marshy areas (Smith 1986: 22-24; Steponaitis 1986: 372; Walker 1998: 143). Certain resources either disappeared from the region or became more difficult/less productive to target (e.g., waterfowl), while others became more common and more productive (e.g., terrestrial mammals and birds, mast species). Patchiness in resource distributions favored a shift to a logistical strategy, as groups began to exploit resources that were differentially available according to spatial and temporal contexts. Mast species, which increased in frequency in the Holocene, represent a highly nutritious food source that was

“patchy,” in the sense that stands of trees were spatially limited and their productive cycles were periodic. The ability to predict annual cycles of high-yield mast species such as hickory seems to have resulted in Middle Archaic populations focusing their settlement and subsistence scheduling within a structured, logistical system.

Patterns noted in the technological data reflect decisions that were made within the context of these changing subsistence choices and settlement strategies. It is clear that toolmakers were making conscious choices in the design, production, use, and discard of implements so as to facilitate the achievement of the subsistence goals in the most efficient manner. The Late Paleoindian and Early Side Notched deposits produced diverse technological assemblages, indicating the exploitation of a varied set of subsistence resources, and the pursuit of a wide range of activities occurring on-site. By the Middle Archaic, technological diversity had decreased substantially, indicating a likely shift in subsistence organization. The great focus on flexible bifacial implements, the abandonment of specialized unifaces, and the great focus on nuts all point to a decrease in the range of activities being carried out at the site, and a decrease in the dietary options being pursued.

These changes were apparent not only in the reduced toolkit diversity but also in the nature of the design choices made in the production of various tool categories. Characteristics of many of the Late Paleoindian tool classes reflect technological decisions that facilitated residential mobility and others that enabled logistical procurement of certain resources. These decisions included the use of high-quality stone in the production of well-made formal tools (e.g., hafted bifaces) that could be resharpened, repaired, and reworked to meet the host of potentially unpredictable needs that might arise over the course of the settlement round. Other

tool classes (e.g., End Scrapers) were well designed in order to remain functional through intensive periods of use on-site.

By the latter part of the Early Archaic and throughout the Middle Archaic, design choices reflected the increasing emphasis on a logistical strategy. Dust Cave began to be used as a special-purpose nut-processing site from which a larger, central base camp would have been provisioned. With the exception of formal bifaces that appear to have been produced for use away from Dust Cave, the majority of tools that were used on-site were expedient implements, with little thought given to their design and manufacture. Use of such tools on a logistical extraction site, where plant food exploitation seems to have been the primary focus, would have ensured that time and energy were not diverted from these subsistence pursuits into the creation of technology and that subsistence activities were carried out as efficiently as possible.

Discard patterns also reflect changing technological choices in response to subsistence pursuits, settlement strategies, and raw material availability. Many of the Late Paleoindian tools revealed evidence for discard prior to tool failure rather than discard at the point of complete exhaustion. A focus on raw material conservation is often seen in the context of the sort of high residential mobility typically considered characteristic of Paleoindian and Early Archaic populations and that would have taken mobile foragers away from preferred raw material sources at certain times of year. At Dust Cave, on the other hand, certain classes of tools were discarded in various states of utility. While the occupants of Dust Cave appear to have been more residentially mobile in the early periods of occupation, their discard of tools prior to complete exhaustion may reflect a) a lack of concern over raw material conservation in a geological context in which knappable stone was relatively ubiquitous, b) organization of the settlement system in such a way as to ensure repeated reuse of a site that lay in close proximity to a high-

quality raw material source, and c) logistical exploitation of certain resources in the environs of the cave. The discard of certain tool classes (e.g., End Scrapers) prior to complete exhaustion supports the interpretation of a technology designed for use in a logistical system. These tools may have been replaced in order to facilitate task completion (scraping a hide) without requiring retooling in the midst of use. With the great accessibility of raw materials, producing replacement lithic components in anticipation of intensive periods of use may have been a more efficient strategy than using tools to exhaustion. Pausing to replace an exhausted tool in the middle of an activity may have been viewed as a less efficient use of resources, rather than simply selecting from among a collection of newly minted implements. In this case, conservation efforts seem to have been directed toward minimizing the use of time, rather than minimizing the use of materials.

In the Early Side Notched period, this lack of concern with material conservation appears to have persisted, as many ESN bifaces were discarded without significant evidence for reworking. This behavior likely represents a persistence of the pattern of logistical organization at times of the year.

By the Middle Archaic, when the function of Dust Cave seems to have shifted to a logistical camp where nuts were processed in large quantities, toolmakers seem to have elected to focus on expedient technologies for on-site tool use. These tools appear to have been produced or selected, used, and discarded almost immediately. As nut procurement and processing likely would have been a fairly intensive activity that occurred over a relatively brief interval in the fall, the use of an expedient technology would have ensured that the accomplishment of any tasks not related to nut processing would not have diverted time from the performance of an important subsistence pursuit. Use of an expedient technology may have been facilitated by the

production of bifaces at the site, with appropriate flakes being selected from among the debris created as bifacial tools were manufactured. This strategy would have ensured that little additional time or effort was spent in the completion of these extraneous technological tasks. By the Middle Archaic period, it seems that foragers became intent, in all aspects of their culture, on targeting and using resources efficiently. This goal of efficiency is reflected in logistical subsistence scheduling, the focused use of foods that were simpler to procure and provided more nutritional benefit, and the creation and use of location- or task-specific toolkits.

CONCLUDING REMARKS

The richness of the Southeastern environment, even during the Late Pleistocene, produced a Late Paleoindian and Early Archaic archaeological record that differs in many respects from traces seen elsewhere in North America. The Paleoindian record, in particular, exhibits little resemblance to the stereotypical view of Paleoindians as being residually very mobile and focused on large game hunting. This view grew from observations of impressive proboscidean- and bison-kill sites in the West and the record of focal caribou hunting in the Northeast. The great variety of resources available in the Middle Tennessee River valley in the Late Pleistocene and Early Holocene, including various plant and animal taxa, as well as relatively ubiquitous stone resources, meant that foragers in the region likely felt reduced technological and subsistence stresses compared to other early North American foraging groups. Such a relaxation of environmental constraints is evident in subsistence choices, technological decisions, and settlement patterning. While the Late Paleoindian and Early Archaic inhabitants at Dust Cave do appear to have been more residually mobile than their Middle Archaic successors, it seems that they may have exploited certain resources in a more logistical manner

while using Dust Cave as a “central place.” The ease of raw material availability at Dust Cave and elsewhere in the region produced differing technological patterns than are typical of many Late Paleoindian and Early Archaic sites elsewhere in North America. The great emphasis on expedient flake tools and the discard of implements without maximum utility extraction represent particularly notable differences from the typical Paleoindian pattern and may reflect a balance between residential mobility and logistical resource procurement. As Blue-Grey Fort Payne chert was available so close to the site, and other Fort Payne variants and chert-bearing gravels were available in the region, these foragers were not subject to the same sorts of constraints as mobile populations who occupied geologically patchier environments.

In the Late Paleoindian, Early Side Notched, and even into the Kirk Stemmed period, Dust Cave would have represented an ideal location for a central place. Given the intersection of several biomes rich in varied food resources and the easy availability of stone for the replenishment of toolkits, it is no wonder that Dust Cave became such an attractive locale for return visits by mobile foragers. Many of the food resources exploited during the earliest phases of occupation were lower-ranked items that were harder to process and provided less nutritional benefit. However, the presence of such a wide range of foods in such close proximity to the site may have compensated for reduced nutritional benefits, especially as their exploitation allowed these foragers to gear up toolkits and engage in other important domestic and technological activities (hide scraping, organic tool production) without expending inordinate amounts of time or energy in the accomplishment of subsistence tasks. Environmental changes by the Middle Archaic favored a shift to a more purely logistical strategy, but it is likely that the ease of raw material procurement continued to be a significant factor in drawing people to the site, where hickory nut procurement had become the primary subsistence focus. The production of formal

tools to provision the main base camp, as well as other logistical stations, likely was embedded in the targeted procurement of hickory nuts and representing an efficient balance between subsistence and technological needs.

It is suggested that, during the earliest phases of occupation, the ease of access to stone for lithic production may have been a particularly attractive feature of the site locale for this mobile population. Occupants of the cave clearly were exploiting certain food resources on a seasonal basis, including during the fall and spring, but I expect food was not the only, or even necessarily the primary, reason for using the cave. Instead, a combination of the ease of raw material accessibility and the abundant, easily procured, varied foods available in the immediate environs of the site created an ideal setting for the location of a residential base camp. Foragers used Dust Cave to retool for forays throughout the region, at a location where they could easily meet their subsistence needs in the process.

Use of the site for retooling and general residential activities left a particular technological trace in the Late Paleoindian levels. As toolkits were being replenished at the site, and many of the formal tools (e.g., bifaces) appear to have been produced for use elsewhere, expending additional time and effort in the production of high-quality tools for use at a site located so near the raw material source would not have been the most efficient strategy. Subsistence pursuits undertaken at and around the site would have consumed enough time, as would hide scraping and tool manufacture. Inhabitants of the cave, therefore, made use of an expedient, general-purpose technology while on-site, rather than using formal implements, which a) would have required more time to produce, and b) in the case of bifaces, would have served as an especially flexible form of technology for mobile foragers.

This project took an organizational approach to studying changes in technological patterns from the Late Paleoindian through the Middle Archaic at Dust Cave. While technological patterns exhibited great continuity in some aspects through time, this apparent continuity masks subtle changes in the ways the technology was organized in order to articulate with other elements of the cultural system. Consistency is noted in the use of Blue-Grey Fort Payne chert, the production of hafted bifaces, and the use of expedient flake tools in all periods of occupation, suggesting that Dust Cave toolmakers were making similar technological decisions over several millennia. A more profound examination of technological patterns, however, reveals a shift from a technology that was designed to facilitate a residually mobile strategy and periods of intensive processing using highly specialized tools, to a technology that appears to have been designed in order to provision base camps and activity loci within a logistical strategy and to fulfill the need for flexibility in technologies as part of this new settlement pattern.

A technological organization approach, such as that employed in this study, allows us to consider these changes by examining decisions that were made at the levels of raw material procurement, tool design, manufacture, maintenance, and discard. These decisions are made within the context of particular natural and social environmental circumstances and are aimed at allowing human populations to engage with and adapt to those environments most efficiently. This context-dependent and adaptive perspective that is the hallmark of the Organization of Technology approach is also the reason that this perspective overlaps so well with models of human behavior derived from Behavioral Ecology. In anthropological studies, we borrow from Behavioral Ecology in order to understand the variety of decisions (subsistence, settlement, technological, social) that people make in order to enable efficient articulation with the natural

environment. These two approaches are particularly complementary, as technologies tend to be organized in such a way as to allow the accomplishment of subsistence goals, which are organized and ranked according to the constraints and opportunities presented by the natural and social environments.

On the whole, the results of this particular project were not entirely surprising, given the interpretations of settlement patterns, subsistence practices, and site use that have been generated by prior research at Dust Cave. In spite of the relatively straightforward conclusions drawn in this study, the Dust Cave project as a whole, and this particular contribution to it, highlight some important lessons for archaeological practice. First, an Organization of Technology approach offers great potential for studying the human past. In a sub-discipline of archaeology that has sometimes lagged in theory building, the development of this perspective has provided a means for lithic analysts to access understandings of broader cultural behaviors by using what is one of the most common and lasting classes of artifacts recovered from the human past. Being able to examine lifeless stone tools, and in those artifacts to witness the decisions of toolmakers regarding their participation in a very real and dynamic natural and social environment, brings individual human agents from the past into sharper relief and reveals their adaptability, ingenuity, and rationality.

Second, the work carried out at Dust Cave over the last two decades should reinforce the value of a multidisciplinary approach in archaeological research. The entire project has brought together specialists in paleoclimate, geomorphology, geochemistry, paleoethnobotany, faunal analysis, prehistoric technologies, and human skeletal remains. Each of these areas of specialty has contributed important insight into site use and the position of Dust Cave in the regional context, both at particular times and across the nearly 7,000 year history of its occupation. Of

course such specialized analyses may not be carried out on all projects, as not all archaeological sites exhibit the integrity or levels of preservation seen at Dust Cave. But, as Hollenbach (2005) emphasizes, even on sites where organic preservation is poor, we may use regional environmental reconstructions, along with appropriate models from Evolutionary Ecology, in order to create frameworks for understanding the sorts of subsistence decisions that likely were being made and the environmental challenges that were being faced by foragers. Adding to this, we may incorporate an Organization of Technology approach to interpret further a broad range of forager decisions, even when lithics are the only class of artifacts recovered.

Finally, this project highlights the utility of tackling archaeological analyses from multiple theoretical perspectives. Our discipline has struggled, throughout its history, with heated and often unproductive debates between theorists. We now seem to have reached a point where we see the utility of varied theoretical approaches for addressing different sorts of questions or for interpreting different types of data. Both Hollenbach (2005) and Carmody (2009) borrowed models from Evolutionary Ecology in order to understand the subsistence decisions that foragers were making in the context of a shifting environment. In the work presented here, Technological Organization was used in order to interpret changing technological strategies as a means of meeting dynamic environmental constraints. Each of these studies has pointed to similar patterns of human behavior, reinforcing the hypothesis that these forager populations created and modified all facets of their culture in order to facilitate efficient adaptation to their environments. By taking this sort of multidisciplinary and varied theoretical approach to addressing questions of human behavior, archaeologists can have great success in telling robust stories about the human past.

The research potential for Dust Cave is far from exhausted. Further analyses are certainly warranted, and should provide even more comprehensive insights into the nature of forager adaptations in the Midsouth. While I have attempted a detailed analysis of the chipped stone tools from the site, a detailed examination of the debitage is still warranted. The debris from tool manufacture and maintenance on-site should provide additional insight into the organizational strategies being employed in the technological process, and might allow the application of Surovell's (2012) models to understanding the intersection of adaptive patterns from the combined perspectives of Technological Organization and Behavioral Ecology. A study of these issues using combined datasets (lithic, paleoethnobotanical, and faunal) might also aid in confirming or rejecting the suggestions outlined in this dissertation. Finally, it is important to remember that Dust Cave is only one site, and may or may not be representative of the activities being carried out in the Middle Tennessee River Valley. A consideration of the subsistence and technological patterns from the many other sites in the surrounding region might provide further insight into the role of Dust Cave in the larger regional settlement system.

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VITA

Katherine McMillan was born October 25, 1977 in Burlington, Ontario, Canada. In 2000, she received a B.A. in Anthropology from McMaster University in Hamilton, Ontario. She then attended the University of Western Ontario (now Western University) in London, Ontario, where she pursued an M.A. in Bioarchaeology. After graduating in 2003, she worked in the CRM industry for two years before moving to Knoxville to attend the University of Tennessee where she earned her PhD in Anthropology in 2016.